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Thermophysical Properties of High Temperature Solid Materials

VOLUME 4: OXIDES AND THEIR SOLUTIONS AND MIXTURES Part 1: Simple Oxygen Compounds and Their Mixtures

Thermophysical Properties Research Center, Purdue University

Y. S. TOULOUKIAN, Editor

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Thermophysical Properties of High Temperature Solid Materials

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Thermophysical Properties of High Temperature Solid Materials

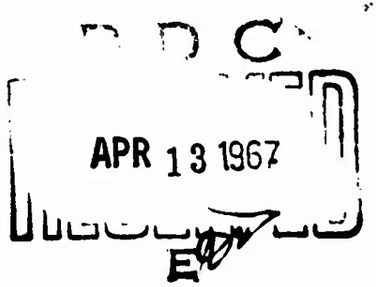
VOLUME 4: OXIDES AND THEIR SOLUTIONS AND MIXTURES □ Part I: Simple Oxygen Compounds and Their Mixtures

Thermophysical Properties Research Center
PURDUE UNIVERSITY

Y. S. Touloukian, EDITOR

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PREFACE

The phenomenal growth of science and technology since the early forties has brought about a universal appreciation of the fact that present limitations in many technical developments are often a direct result of the paucity of knowledge on the properties of materials. Engineering developments in the years ahead will be closely linked to the research that is done today to contribute to a better understanding of the properties of matter, of which thermophysical properties constitute a major segment.

With a realization of the seriousness of this situation, a great deal of research effort has been made in recent years on the thermophysical properties of materials with the result that the volume of research literature has increased many fold. In spite of this fact, it is generally agreed that the present level of research on thermophysical properties still falls substantially short of existing needs and anticipated future demands. However, what is even more disturbing is the fact that engineering groups across the nation are using no more than a fraction of the information already available, either because it is in a form not directly useful to them or, often, because its existence is not generally known.

To partially remedy this situation concerning the thermophysical properties of high temperature materials, the Materials Laboratory of the U.S. Air Force at Wright-Patterson Air Force Base sponsored a project in 1957 to bring together a large portion of the then available data in a single work for easy reference. From this compilation, performed by the Armour Research Foundation, a four-volume work entitled *Handbook of Thermophysical Properties of Solid Materials* emerged. It was first published in 1960 as WADC TR58-476; in 1961 it was issued as a hard-bound set by The Macmillan Company.

Because of the favorable reception given to this original work, the Materials Laboratory of the U.S. Air Force requested the Thermophysical Properties Research Center (TPRC), in 1964, to update and revise this reference work in order to increase its usefulness and to put it on a more current basis. The present six-volume work, entitled *Thermophysical Properties of High Temperature Solid Materials*, consists of nine books totaling more than 8,500 pages. It is the result of a two-year project by TPRC. This new encyclopedic reference work cannot be called a revised edition of the earlier publication since nearly every page has been changed through major additions, corrections, and re-evaluation. An effort was made to adhere to the basic format of the earlier work. However, the organization of the material and the index to materials have been completely redesigned for greater ease in locating the information desired.

Inevitably, not all of the properties covered have received the same degree of attention. The material on thermal radiative properties, thermal diffusivity, and specific heat has been totally revised and rewritten. Materials on the coefficient of thermal expansion and thermal conductivity have received major revisions, and those on electrical resistivity, density, and melting point have had moderate revisions. Finally, lesser revisions were made to data concerning vapor pressure and heats of transformation. The new information incorporated into the work covered research conducted primarily during the years 1957 to 1964, although some major references are included from 1965 and some from as far back as 1910.

In processing the large amount of new and old data incorporated in these volumes, it was necessary that some degree of selectivity be exercised both from the standpoint of the references cited and the data extracted from them. It is hoped, however, that no major source of information has been omitted. Whenever possible, an effort was made to suggest recommended values of the properties. In the plots, recommended values are indicated by curves. It should be clear, however, that the designation of "recommended values" in no way implies that a critical analysis has been performed in all cases, nor does it suggest that they repre-

sent definitive values. Because most of the materials covered are not well-defined engineering materials, and because there is often a great paucity of information, any critical evaluation of these data is most difficult—if not impossible.

With a full appreciation of these inherent difficulties it is nevertheless hoped that the present compendia will prove to be of great usefulness to engineers seeking information on thermophysical properties. In spite of the extreme care exercised in processing the data and proofing the manuscript, it is possible that some errors might have been inadvertently overlooked. Should any instance of such oversight be uncovered, the Editor would be most indebted if it is brought to his attention.

The fact that such an enormous undertaking could be accomplished in such a short time is attributable primarily to TPRC's unique resources in the area of thermophysical properties information. Grateful acknowledgment is made to the Electronic Properties Information Center for assistance in providing bibliographic searches on electrical resistivity and to the Air Force Materials Laboratory for general assistance in bibliographic information. Extensive personal inquiries were made to the authors of research papers and reports requesting clarification and original data. The enthusiastic response to these inquiries (in the majority of the cases) is also gratefully acknowledged. The Editor and the contributing staff wish to give a special note of thanks in acknowledging the valuable assistance and cooperation they received individually and collectively from TPRC's Scientific Documentation Division personnel and the supporting staff of graphics and technical typists without whose painstaking and skillful contributions this work would not have been possible.

This work was performed under Contract No. AF33(615)1642, sponsored by the Air Force Materials Laboratory, Research and Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio. The personnel directly affiliated with this program were Mr. D. A. Shinn, Chief, Materials Information Branch; Mr. E. Dugger, Technical Manager, Information Processing; and Mr. J. H. Charlesworth, engineer in charge of this project. Their understanding cooperation has contributed much to the success of the program.

It is sincerely hoped that *Thermophysical Properties of High Temperature Solid Materials* will constitute an even more valuable contribution to technology than its predecessor. This work should prove to be an invaluable source of information on an important group of properties of materials to every engineer, providing him with reliable information of a scope that would be impossible for any one individual to master. If we have been able to approach these goals, the results will be highly gratifying.

June 1966

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EXPLANATORY TEXT

I. SCOPE OF COVERAGE

Thermophysical Properties of High Temperature Solid Materials comprises six volumes. Volumes 2, 4, and 6 each consist of two parts because of the large amount of material covered. The general contents of the respective volumes are as follows:

Volume 1—Elements
Volume 2—Nonferrous Alloys
  PART I—Nonferrous Binary Alloys
  PART II—Nonferrous Multiple Alloys
Volume 3—Ferrous Alloys
Volume 4—Oxides and Their Solutions and Mixtures
  PART I—Simple Oxygen Compounds and Their Mixtures
  PART II—Solutions and Their Mixtures of Simple Oxygen Compounds, Including Glasses and Ceramic Materials
Volume 5—Nonoxides and Their Solutions and Mixtures, Including Miscellaneous Ceramic Materials
Volume 6—Intermetallics, Cermets, Polymers, and Composite Systems
  PART I—Intermetallics
  PART II—Cermets, Polymers, and Composite Systems

The specific properties covered in each volume are:

1. Density (ρ)
2. Melting Point (M. P.)
3. Heat of Fusion (Δh_f)
4. Heat of Vaporization (Δh_v)
5. Heat of Sublimation (Δh_s)
6. Electrical Resistivity (r)
7. Specific Heat at Constant Pressure (c_p)
8. Thermal Conductivity (k)
9. Thermal Diffusivity (α)
10. Thermal Linear Expansion ($\Delta L/L$)
11. Thermal Radiative Properties:
    Absorptance (α), Emittance (ϵ), Reflectance (ρ), and Transmittance (τ)
12. Vapor Pressure (p)

Generally, only materials with melting points above 800°K (approximately 1000°F) are included, except for materials within the categories of polymers, plastics, and composites. A detailed discussion of the material classification procedure is presented in the following sections. A Material Index for the entire work is included at the end of each volume.

II. TPRC CLASSIFICATION OF MATERIALS

Materials are classified into the eight categories listed below. Whenever applicable, the compositions are reported in weight percent of the constitutents. For purposes of material classification TPRC considers the following elements as nonmetallic: H, He, C, N, O, F, Ne, P, S, Cl, A, Br, Kr, I, Xe, At, and Rn.

1. *Elements*: For the purpose of classification an element is specified as follows:
   A. For metallic elements, the limit of impurities is <0.20 percent for each foreign constituent and <0.50 percent total impurities.
   B. For nonmetallic elements (i.e., carbon including graphite and diamond), the limit of impurities is ≤ 2.0 percent for each foreign constituent and ≤ 5.0 percent total impurities.
2. *Nonferrous Alloys*: This category is for alloys in which the major constituent is other than iron. For the purpose of classification, nonferrous alloys are specified as follows:
   A. Nonferrous Binary Alloys: The sum of the binary constituents is ≥ 99.5 percent and other constituents ≤ 0.20 percent each.
   B. Nonferrous Multiple Alloys: The sum of the first two constituents is <99.50 percent and/or any other constituent >0.20 percent. Alternatively, the major constituent is ≤ 99.50 percent and each of the other constituents <0.20 percent (or not given).
3. *Ferrous Alloys*: This category is for alloys in which iron is greater than or equal to any other constituent. For the purpose of classification, ferrous alloys are specified as follows:
   A. Carbon Steels: Carbon ≤ 2.0 percent and carbon $\geq$ any other alloying constituent.
      a. Group I: Every other alloying constituent is ≤ 0.20 percent except for Mn, P, S, Si, which may be ≤ 0.60 percent each.
      b. Group II: At least one other alloying constituent >0.20 percent and/or any of Mn, P, S, Si >0.60 percent.
   B. Cast Irons: Carbon >2.0 percent and carbon $\geq$ any other alloying constituent.
      a. Group I: Every other alloying constituent ≤ 0.20 percent except for Mn, P, S, Si, which may be ≤ 0.60 percent each.
      b. Group II: At least one other alloying constituent >0.20 percent and/or any of Mn, P, S, Si >0.60 percent.
   C. Alloy Steels (including alloy cast iron): The major alloying constituent is other than carbon.
      a. Group I: Every other alloying constituent ≤ 0.20 percent except for Mn, P, S, Si, which may be ≤ 0.60 percent each, and C ≤ 2.0 percent.*
      b. Group II: At least one other alloying constituent >0.20 percent and/or any of Mn, P, S, Si >0.60 percent.*
4. *Nonmetallic Compounds and Their Mixtures and Solutions*: Ceramic materials such as oxides, bromides, carbides, carbonates, nitrides, silicates, etc., are included in this category. For the purpose of classification, they are specified as follows:
   A. For simple compounds and their solutions, the limit of impurities is ≤ 2.0 percent for each foreign constituent and ≤ 5.0 percent total impurities.

---

* Exception is made when Mn, P, S, or Si is the major alloying constituent. For instance, in the case of Fe + Mn + ΣX_i alloys the specifications corresponding to Groups I and II would be as follows:
  a. Group I: Every other alloying constituent ≤ 0.20 percent except for P, S, Si, which may be ≤ 0.60 percent each, and C ≤ 2.0 percent.
  b. Group II: At least one other alloying constituent >0.20 percent and/ any of P, S, Si >0.60 percent.

  In the above example, Mn has a higher weight percentage than any of P, S, or Si but does not necessarily have a weight percentage higher than 0.60 percent. Thus, the limits of Mn percentage may be written:

  Fe $\geq$ Mn $>$ P, S, Si and any other alloying constituent and Mn ≥ 0.20.

  The same guideline is applied to ferrous alloys containing P, S, or Si as major alloying constituents.

B. For mixtures of simple compounds and their solutions, the major constituent is <95.0 percent, or any other constituent is >2.0 percent.

5. *Intermetallics*: An intermetallic is a metal-metal compound formed by metallic elements in a fixed simple atomic ratio. For the purpose of classification, specifications are the same as those for Class 4.
6. *Cermets*: Cermets are ceramic materials such as carbides, oxides, etc., fused with or bonded by one or more pure metals. However, there are also metal-metal cermets, metal-intermetallic cermets, etc., which are also included in this category.
7. *Polymers*: Polymers are chemical compounds or mixtures of compounds formed by polymerization and consisting essentially of repeating molecular structural units.
8. *Composite Systems*: A composite system may consist of materials in combination, with clearly defined boundaries existing between components of the system, or a homogeneous material having a distinct configuration.

For the reader's convenience, the classification scheme for Classes 1 through 4, described above, is summarized in the following table.

SUMMARY TABLE OF TPRC CLASSIFICATION OF MATERIALS

Classification			Limits of Composition (weight percent)			
			X_1	$X_1 + X_2$	X_2	X_3
1. ELEMENTS	A. METALLIC		>99.50	--	<0.20	<0.20
	B. NONMETALLIC		≥95.0	--	≤2.0	≤2.0
2. NONFERROUS ALLOYS (X_1 > Fe)	A. BINARY ALLOYS		--	≥99.50	≥0.20	≤0.20
	B. MULTIPLE ALLOYS		--	≥99.50	>0.20	>0.20
			--	<99.50	≥0.20	≤0.20
			--	<99.50	>0.20	>0.20
			≤99.50	--	<0.20	<0.20
			X_1	X_2	X_3	Mn, P or Si
3. FERROUS ALLOYS (X_1 = Fe ≥ X_2)	A. CARBON STEELS	GROUP I	Fe	C ≤2.0	≤0.20	≤0.60
		GROUP II	Fe	C ≤2.0	≤0.20	>0.60
			Fe	C ≤2.0	>0.20	≤0.60
			Fe	C ≤2.0	>0.20	>0.60
	B. CAST IRONS	GROUP I	Fe	C >2.0	≤0.20	≤0.60
		GROUP II	Fe	C >2.0	≤0.20	>0.60
			Fe	C >2.0	>0.20	≤0.60
			Fe	C >2.0	>0.20	>0.60
	C. ALLOYS* STEELS	GROUP I	Fe	≠C	≤0.20 and C ≤2.0	≤0.60
		GROUP II	Fe	≠C	≤0.20	>0.60
			Fe	≠C	>0.20	≤0.60
			Fe	≠C	>0.20	>0.60

4. NONMETALLIC COMPOUNDS AND THEIR MIXTURES AND SOLUTIONS

	X_1	X_2
A. SIMPLE COMPOUNDS AND THEIR SOLUTIONS	≥95.0	≤2.0
B. MIXTURES OF SIMPLE COMPOUNDS AND THEIR SOLUTIONS	<95.0	≤2.0
	≥95.0	>2.0
	<95.0	>2.0

NOMENCLATURE:

X_1 = Major Constituent

X_2 = Second Highest Constituent

X_3 = Third Highest Constituent

Where: $X_1 \geq X_2 \geq X_3 \geq X_4 \geq \cdots\cdots$

*In case Mn, P, S, or Si represents X_2 this particular element is dropped from the last column.

III. PRESENTATION OF DATA

Each of the six volumes consists of seven sections arranged in the following order:

1. Preface
2. Table of Contents
3. Explanatory Text
4. Conversion Factors
5. Body of Data
6. References
7. Material Index.

In the following paragraphs a detailed description of Sections 5, 6, and 7 is given. The contents of the first four sections are self-explanatory.

BODY OF DATA

Data on each material are presented in graphical or tabular form for selected sets of measurements, and are accompanied by a Reference Information Table with corresponding specifications and remarks. The first five properties listed in Section I of this Explanatory Text are considered as *point values* and are grouped together in a single table in the same manner as the graphs for the other remaining properties. Furthermore, for a given material group, where several properties are reported, data are arranged in accordance with the order of the property list given in Section I of this text.

Graphic Presentation

Data extracted from various references on a given material and property are shown on a single graph by means of distinct plotting symbols, which are identified in the Reference Information Table on the page following the graph. Each set of symbols indicates the data of a given investigator, but does not necessarily imply actual measured points. In numerous instances authors present only smoothed values, either in graphical or tabular form, and it is frequently impossible to distinguish interpolated or smoothed values from actual observed data.

In reporting data on thermal linear expansion, investigators sometimes give a single average value of this property for a considerable temperature range. In such instances it is assumed that a linear relationship is implied. All data on thermal linear expansion were reduced to a datum of 293°K (20°C); i.e., $(\Delta L/L) = 0$ at 293°K (20°C). This point is identified by a cross (+) on each graph.

The definition of $(\Delta L/L)$ used in this work is

$$(\Delta L/L) = \frac{L_T - L_{293}}{L_{293}} \times 100$$

where L_T = length of specimen at temperature T.

L_{293} = length of specimen at 293°K (20°C).

To compute the "coefficient" of thermal linear expansion β from 293°K to any temperature T, the following relation may be used.*

$$\beta = \frac{1}{100\,(T - 293)} \frac{\Delta L}{L}, \text{ in } K^{-1}$$

* It is necessary to divide the right-hand side of this equation by 100 because the graphical presentation of $(\Delta L/L)$ is in percent expansion from 293°K.

In some instances the coefficient of thermal linear expansion is reported in tabular form.

Curves drawn through the plotted points are the "most probable" curves based on the data shown. As additional information becomes available in the future, these recommendations may well be modified.

Point Value Table

Data extracted from various references are identified by distinct symbols in the same manner as data points on a graph. "Most probable" values are given either at the top of the table or are indicated in a footnote. These selections are usually made solely on the basis of the data presented. Sometimes these point values are also reported as a function of temperature or composition, in which case they are shown in graphical form and placed immediately following the tabular values.

Reference Information Table

A table giving the reference information associated with each set of data obtained in the graph immediately follows the graph. The table contains the following information:

1. Symbol. The plotting symbols are identical with and correspond to those used in the graph.
2. Reference. References are identified by hyphenated numbers which serve to locate the bibliographic citation in the section of References at the end of each volume. The initial two digits indicate the year of publication and the last digits identify the specific reference within the given year. In those instances where a reference does not carry a date, the letter symbol ND is used in place of the year of publication. Undated references are listed at the end of the list of References.
3. Temperature Range. Range covered by the data in a given paper or report.
4. Reported Error. The author's estimated accuracy (or precision).
5. Sample Specification. This column contains all pertinent available information about the test sample. This information consists of the following:
   a. Commercial trade name, chemical formula, etc., followed by manufacturer's name, if it is necessary for correct identification.
   b. Composition of the sample, expressed in weight percent. Unless otherwise stated, the percent sign is omitted.
   c. Physical characteristics of the material, such as a single crystal, polycrystalline, density, crystal structures, etc.
   d. Specimen designation by the author is given in brackets at the end of the citation.
6. Remarks. This column contains information on:
   a. Special process used in fabrication of the sample, such as being sintered, chill-cast, etc.
   b. Sample history, such as cold-worked, hot-pressed, annealed, etc.
   c. Conditions under which the specimen was investigated, environment, etc.
   d. Other pertinent remarks.

REFERENCES

The section on Reference gives complete bibliographic citations for all the references from which data were extracted. They are arranged chronologically by year of publication, and in arbitary sequence within any given year.

For the preparation of the references, the following order and convention is used.

Periodicals

1. Author(s) name: Last name first, followed by initials.
2. Journal name: Standard TPRC journal name abbreviations are used.
3. Series, volume, and number.

a. If the series is represented by a letter, it is underlined together with the volume number.
b. If the series is represented by a number, then only the numeral representing the volume is underlined.
c. The numeral for the issue number is shown in parentheses.

4. Pages: Indicate the beginning and ending pages.

Reports

1. Author(s) name is given in the same form as for periodicals.
2. The name of the responsible organization, if any.
3. The name of sponsor.
4. Report, bulletin, or circular designation.
5. Number.
6. Part.
7. Pages (same as for periodicals).
8. AD and PB numbers or equivalents.

Books

The bibliographic citation for books lists: author(s), title, volume, edition, publisher, and page(s).

In general, private communications are not listed as references. However, if TPRC did obtain additional substantive information from an author through private communication, and if this information was used, the remark "additional data obtained from author(s)" is added at the end of the reference citation.

MATERIAL INDEX

The Material Index lists all the materials included in this work by their proper trade or commercial names arranged in alphabetical order and, for materials designated by number codes, the listing is in increasing numerical order. Location of information on a particular property for a particular material is specified by the volume number and page numbers indicated within the appropriate property column of the index. The page number always indicates the starting page of the graphs or point value tables. Chemical formulas are given in parentheses following the proper names of materials which can be chemically identified. However, for materials within a general group, e.g., different oxides of cerium, the entries are only by chemical formulas listed under the material group designation, such as "cerium oxides." Whenever applicable, an effort is made to list commercial materials under their several accepted names. In the case of broad classes of materials, such as steels, glasses, etc., the materials are listed under their common names as well as under the heading of their general class when the designation is merely a letter and number code.

Simpler inorganic compounds (e.g., aluminum oxide, tantalum boride) are named according to the convention given in the *Handbook of Chemistry and Physics* (The Chemical Rubber Co., 45th edition, 1964, and—if not available there—the 43rd edition, 1962). Other inorganic compounds are generally named in accordance with the convention given in the *Chemical Abstracts* by giving the more electropositive part of the name first and the more electronegative part second. For nonferrous and ferrous alloys, only the first two components are listed and ΣX_i is added to designate multiple alloys. An exception is made, however, for chromium-nickel and nickel-chromium ferrous alloys, in which cases, all three major constituents are listed. For other inorganic compounds and their mixtures and solutions, all components with weight percent greater than 2 percent are listed. Finally, for cermets, the name of the ceramic part is given first and the metal part second, each in their respective alphabetical order regardless of their weight percentages, with the exception of beryllium cermet (e.g., Beryllium YB-9052), in which case the name of the metal part is given first.

CONVERSION FACTORS

NOTE: In preparing the conversion factors, the following basic definitions were used:

$$1 \text{ in.} = 2.54 \text{ cm}^*$$

$$1 \text{ lb.} = 453.59237 \text{ g}^*$$

$$1 \text{ cal}_{\text{Th}} = 4.184 \text{ (exactly) Joule}^*$$

$$1 \text{ cal}_{\text{IT}} = 4.1868 \text{ (exactly) Joule}^*$$

$$1 \text{ Btu}_{\text{IT}}\text{lb}^{-1}\text{F}^{-1} = 1 \text{ cal}_{\text{IT}}\text{g}^{-1}\text{C}^{-1}\ddagger$$

The subscripts "Th" and "IT" denote "Thermochemical" and "International Steam Table" units, respectively.

---

* *NBS Technical News Bulletin*, **47**(10), 1963.

‡ Mueller, E. F., and Rossini, F. D., *Am. J. Physics*, **12**(1), 4, 1944.

CONVERSION FACTORS FOR UNITS OF DENSITY

MULTIPLY by appropriate factor to OBTAIN →	g cm^{-3}	g $in.^{-3}$	kg m^{-3}	kg ft^{-3}	lb $in.^{-3}$	lb ft^{-3}
g cm^{-3}	1	1.63872×10	1.0×10^{3}	2.83170×10	3.61275×10^{-2}	6.24283×10
g $in.^{-3}$	6.10234×10^{-2}	1	6.10234×10	1.72800	2.20462×10^{-3}	3.80959
kg m^{-3}	1.0×10^{3}	1.63872×10^{-2}	1	2.83170×10^{-2}	3.61275×10^{-5}	6.24283×10^{-2}
kg ft^{-3}	3.51446×10^{-2}	5.78704×10^{-1}	3.53145×10	1	1.27582×10^{-3}	2.20462
lb $in.^{-3}$	2.76797×10	4.53592×10^{2}	2.76797×10^{4}	7.83808×10^{2}	1	1.72800×10^{3}
lb ft^{-3}	1.60184×10^{-2}	2.62496×10^{-1}	1.60184×10	4.53592×10^{-1}	5.78704×10^{-4}	1

CONVERSION FACTORS FOR UNITS OF LATENT HEAT

MULTIPLY by appropriate factor to OBTAIN →	$cal_{Th}\,g^{-1}$	$cal_{IT}\,g^{-1}$	W sec g^{-1}	$J_{Int}\,g^{-1}$	$Btu_{Th}\,lb^{-1}$	$Btu_{IT}\,lb^{-1}$
$cal_{Th}\,g^{-1}$	1	9.99331×10^{-1}	4.184	4.18331	1.8	1.79880
$cal_{IT}\,g^{-1}$	1.00067	1	4.1868	4.18611	1.80120	1.8
W sec g^{-1}	2.39006×10^{-1}	2.38846×10^{-1}	1	9.99835×10^{-1}	4.30210×10^{-1}	4.29923×10^{-1}
$J_{Int}\,g^{-1}$	2.39045×10^{-1}	2.38885×10^{-1}	1.00017	1	4.30281×10^{-1}	4.29994×10^{-1}
$Btu_{Th}\,lb^{-1}$	5.55556×10^{-1}	5.55184×10^{-1}	2.32444	2.32406	1	9.99331×10^{-1}
$Btu_{IT}\,lb^{-1}$	5.55927×10^{-1}	5.55556×10^{-1}	2.32	2.32562	1.00067	1

CONVERSION FACTORS FOR UNITS OF SPECIFIC HEAT

MULTIPLY by appropriate factor to OBTAIN →	$cal_{Th}g^{-1}C^{-1}$	$cal_{IT}g^{-1}C^{-1}$	W sec $g^{-1}K^{-1}$	$J_{Int}g^{-1}K^{-1}$	$Btu_{Th}lb^{-1}F^{-1}$	$Btu_{IT}lb^{-1}F^{-1}$
$cal_{Th}g^{-1}C^{-1}$	1	9.99331×10^{-1}	4.184	4.18331	1	9.99331×10^{-1}
$cal_{IT}g^{-1}C^{-1}$	1.00067	1	4.1868	4.18611	1.00067	1
W sec $g^{-1}K^{-1}$	2.390006×10^{-1}	2.38846×10^{-1}	1	9.99835×10^{-1}	2.39006×10^{-1}	2.38846×10^{-1}
$J_{Int}g^{-1}K^{-1}$	2.39045×10^{-1}	2.38885×10^{-1}	1.00017	1	2.39045×10^{-1}	2.38885×10^{-1}
$Btu_{Th}lb^{-1}F^{-1}$	1	9.99331×10^{-1}	4.184	4.18331	1	9.99331×10^{-1}
$Btu_{IT}lb^{-1}F^{-1}$	1.00067	1	4.1868	4.18611	1.00067	1

Note: To convert quantities per "gram" to "mol" basis multiply conversion factor by the molecular weight M.

CONVERSION FACTORS FOR UNITS OF THERMAL CONDUCTIVITY

MULTIPLY by appropriate factor to OBTAIN →	$Btu_{IT} hr^{-1} ft^{-1} F^{-1}$	$Btu_{IT} in. hr^{-1} ft^{-2} F^{-1}$	$cal_{IT} sec^{-1} cm^{-1} C^{-1}$	$cal_{Th} sec^{-1} cm^{-1} C^{-1}$	$kcal_{Th} hr^{-1} m^{-1} C^{-1}$	$W\ cm^{-1} K^{-1}$
$Btu_{IT} hr^{-1} ft^{-1} F^{-1}$	1	1.2 x 10	4.13379×10^{-3}	4.13656×10^{-3}	1.48916	1.73073×10^{-2}
$Btu_{IT} in. hr^{-1} ft^{-2} F^{-1}$	8.33333×10^{-2}	1	3.44482×10^{-4}	3.44713×10^{-4}	1.24097×10^{-1}	1.44228×10^{-3}
$cal_{IT} sec^{-1} cm^{-1} C^{-1}$	2.41909×10^{2}	2.90291×10^{3}	1	1.00067	3.60241×10^{2}	4.1868
$cal_{Th} sec^{-1} cm^{-1} C^{-1}$	2.41747×10^{2}	2.90096×10^{3}	9.99331×10^{-1}	1	3.6×10^{2}	4.184
$kcal_{Th} hr^{-1} m^{-1} C^{-1}$	6.71520×10^{-1}	8.05824	2.77592×10^{-3}	2.77778×10^{-3}	1	1.16222×10^{-2}
$W\ cm^{-1} K^{-1}$	5.77789 x 10	6.93347×10^{2}	2.38846×10^{-1}	2.39006×10^{-1}	8.60421 x 10	1

CONVERSION FACTORS FOR UNITS OF THERMAL DIFFUSIVITY

MULTIPLY by appropriate factor to OBTAIN →	cm^2sec^{-1}	cm^2hr^{-1}	m^2hr^{-1}	$in.^2sec^{-1}$	ft^2sec^{-1}	ft^2hr^{-1}
cm^2sec^{-1}	1	3.60×10^{3}	3.60×10^{-1}	1.550×10^{-1}	1.07639×10^{-3}	3.87501
cm^2hr^{-1}	2.77778×10^{-4}	1	1.0×10^{-4}	4.30556×10^{-5}	2.98998×10^{-7}	1.07639×10^{-3}
m^2hr^{-1}	2.77778	1.0×10^{4}	1	4.30556	2.98998×10^{-3}	1.07639×10
$in.^2sec^{-1}$	6.45160	2.32258×10^{4}	2.32258	1	6.94444×10^{-3}	2.50×10
ft^2sec^{-1}	9.29030×10^{2}	3.34451×10^{6}	3.34451×10^{2}	1.440×10^{2}	1	3.60×10^{3}
ft^2hr^{-1}	2.58064×10^{-1}	9.29030×10^{2}	9.29030×10^{-2}	4.0×10^{-2}	2.77778×10^{-4}	1

CONVERSION FACTORS FOR UNITS OF VAPOR PRESSURE

MULTIPLY by appropriate factor to OBTAIN →	dyne cm^{-2}	atm	kg cm^{-2}	mm Hg	in. Hg	lb $in.^{-2}$
dyne cm^{-2}	1	9.8690×10^{-7}	1.01970×10^{-6}	7.5010×10^{-4}	2.9530×10^{-5}	1.45040×10^{-5}
atm	1.01330×10^{6}	1	1.03320	7.60×10^{2}	2.9920×10	1.46960×10
kg cm^{-2}	9.8070×10^{5}	9.6780×10^{-1}	1	7.3560×10^{2}	2.8960×10	1.42230×10
mm Hg	1.33320×10^{3}	1.31580×10^{-3}	1.35950×10^{-3}	1	3.9370×10^{-2}	1.93370×10^{-2}
in. Hg	3.3860×10^{4}	3.3420×10^{-2}	3.4530×10^{-2}	2.540×10	1	4.9120×10^{-1}
lb $in.^{-2}$	6.89470×10^{4}	6.80460×10^{-2}	7.0310×10^{-2}	5.1710×10	2.0360	1

BODY OF DATA

OXIDES AND THEIR SOLUTIONS AND MIXTURES

PART I

SIMPLE OXYGEN COMPOUNDS AND THEIR MIXTURES

NOTE: For purpose of classification, simple oxygen compounds and their mixtures are specified as follows:

1. For simple compounds, the limit of impurities is ≤ 2.0 percent for each foreign constituent and ≤ 5.0 percent total impurities.
2. For mixtures of simple compounds, the major constituent is < 95.0 percent, or any other constituent is > 2.0 percent.

PROPERTIES OF ALUMINUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density	4.0	250
Melting Point	2316	4169
Heat of Sublimation . . .	4473_{298K}	8052_{537R}

REPORTED VALUES

Density		$g\ cm^{-3}$	$lb\ ft^{-3}$
	○	4.0	250
	◁	3.4	212
	▷	3.559 ± 0.001	222.18 ± 0.06
	●	3.9	243

Melting Point		K	R
	△	2293	4127
	◇	2298	4136
	▽	2316	4169
	▲	2323	4181
	◀	2315 ± 7	4167 ± 13
	▶	2307 ± 16	4153 ± 29

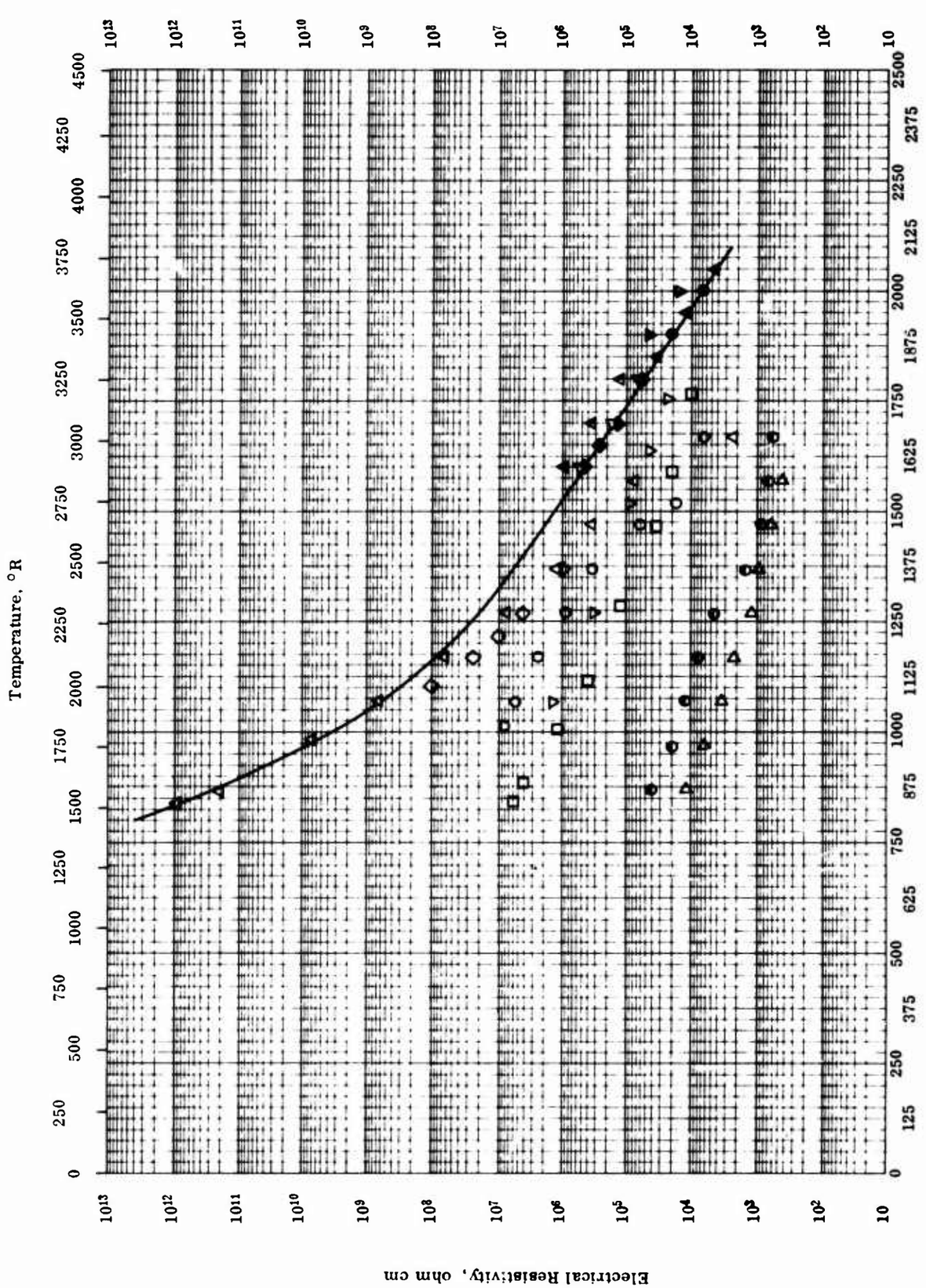
Heat of Sublimation		$cal\ g^{-1}$	$Btu\ lb^{-1}$
	■	1472_{2223K}	2650_{4002R}
	□	4473_{298K}	8052_{537R}

PROPERTIES OF ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-7	298		α - phase.	
◁	52-7	298		γ - phase.	
■	52-7	2223			Δh_s from vapor pressure data.
□	51-5	298			Δh_s from vapor pressure data, assuming Al_2O_3 (s) → 2 Al (g) + 1/2 O_2 (g).
◀	54-26	2308-2322	±2		M. P. by visual observation.
▷	57-13	298			Sintered; density by weight in air and in water.
▶	52-15	2291-2323		99.5+ pure, Alcoa T-61 grade.	M. P. by visual observation.
●	60-22	298			
△	59-10	2293		Not given.	Obtained by observation of sample during heating; reflection error possible.
◇	60-23	2298		About 99.9 pure.	Obtained by observation of bar-shaped sample during cooling; emissivity stated by authors to be about unity.
▽	61-26	2306-2326		Not given.	Obtained by observation of sample suspended in furnace during heating.
▲	64-9	2323		Not given.	

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ELECTRICAL RESISTIVITY -- ALUMINUM OXIDE

ELECTRICAL RESISTIVITY -- ALUMINUM OXIDE

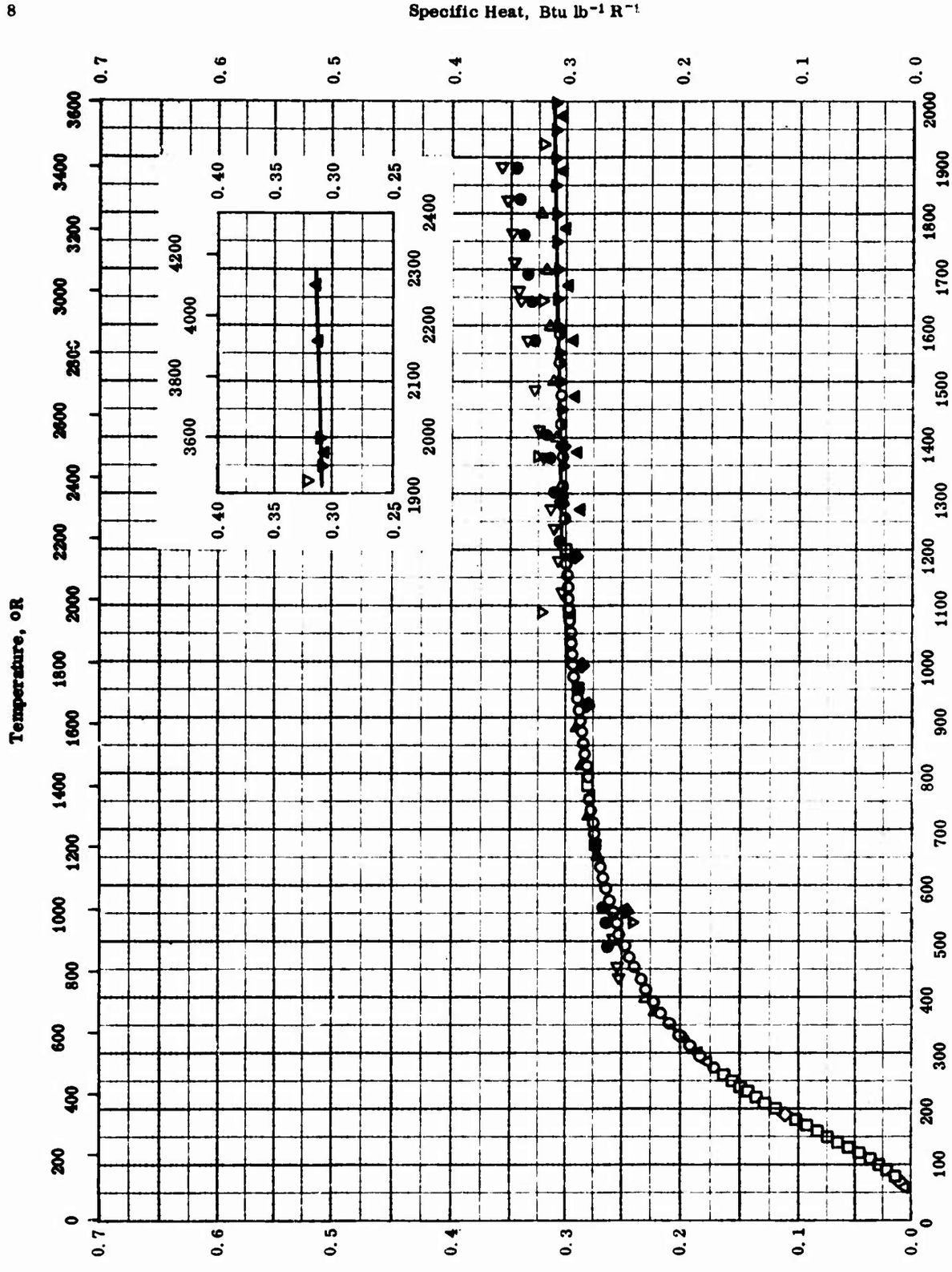
REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
△	54-21	833-1773	→	Al_2O_3, α phase with total impurities < 0.03; prepared from 99.996 Al and triple-distilled H_2O.	Sintered; $Al + H_2O \xrightarrow{Bayerit} Al_2O_3$; heated under $< 10^{-5}$ atm and compressed by hand; shrinkage when fired up to 35%; electrometer accuracy ± 20%, potential drop accuracy ± 5%, and ohm's law holds.
◇	40-3	1103-1273		Al_2O_3; 1 cm cube samples.	Platinized faces; author est. accuracy order of magnitude only.
▽	53-17	1073-1753		Al_2O_3; porosity 27%.	Acid treated Al_2O_3 and fired 10 hrs at 1500 C.
□	53-17	873-1773		Al_2O_3.	Calcined $Al(OH)_3$ and fired 10 hrs at 1500 C.
○	53-16	1013-1673	→	99 Al_2O_3; pyrometric cone equivalent 41-42; porosity 24%.	Measured commercial material; author est. accuracy ± 10% in megohm range, ± 4% in 51 kohm range, ± 3% in 100 ohm range.
▷	53-16	873-1573		Alumina; apparent porosity 3.1%.	Fused and cast at 1930 C.
⊖	53-16	873-1673		Alumina; apparent porosity 4.2%.	Fused and cast at 1940 C.
◁	61-22	1600-1800		Polycrystal; average grain dia 28μ; apparent porosity 3% with 4μ pore size.	Calcining Linde A polishing powder at 1500 C for 10 hrs and then pressing 30,000 psi, and sintering at 1900 C for 7 hrs; measured under 10^{-10} atm pressure; activation energy 2.45 ev.
◐	61-22	1800-2000		Same as above.	Same as above; measured under 10^{-10} atm pressure; activation energy 3.6 ev.

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REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▲	61-22	1600-1800		Same as above.	Same as above; measured under 10^{-5} atm pressure; activation energy 2.40 ev.
▼	61-22	1800-2000		Same as above.	Same as above; measured under 10^{-5} atm pressure; activation energy 3.32 ev.
◆	61-22	1600-1800		Same as above.	Same as above; measured under 1.0 atm pressure; activation energy 2.46 ev.
▲	61-22	1800-2050		Same as above.	Same as above; measured under 1.0 atm pressure; activation energy 3.32 ev.



SPECIFIC HEAT -- ALUMINUM OXIDE

SPECIFIC HEAT -- ALUMINUM OXIDE

REFERENCE INFORMATION

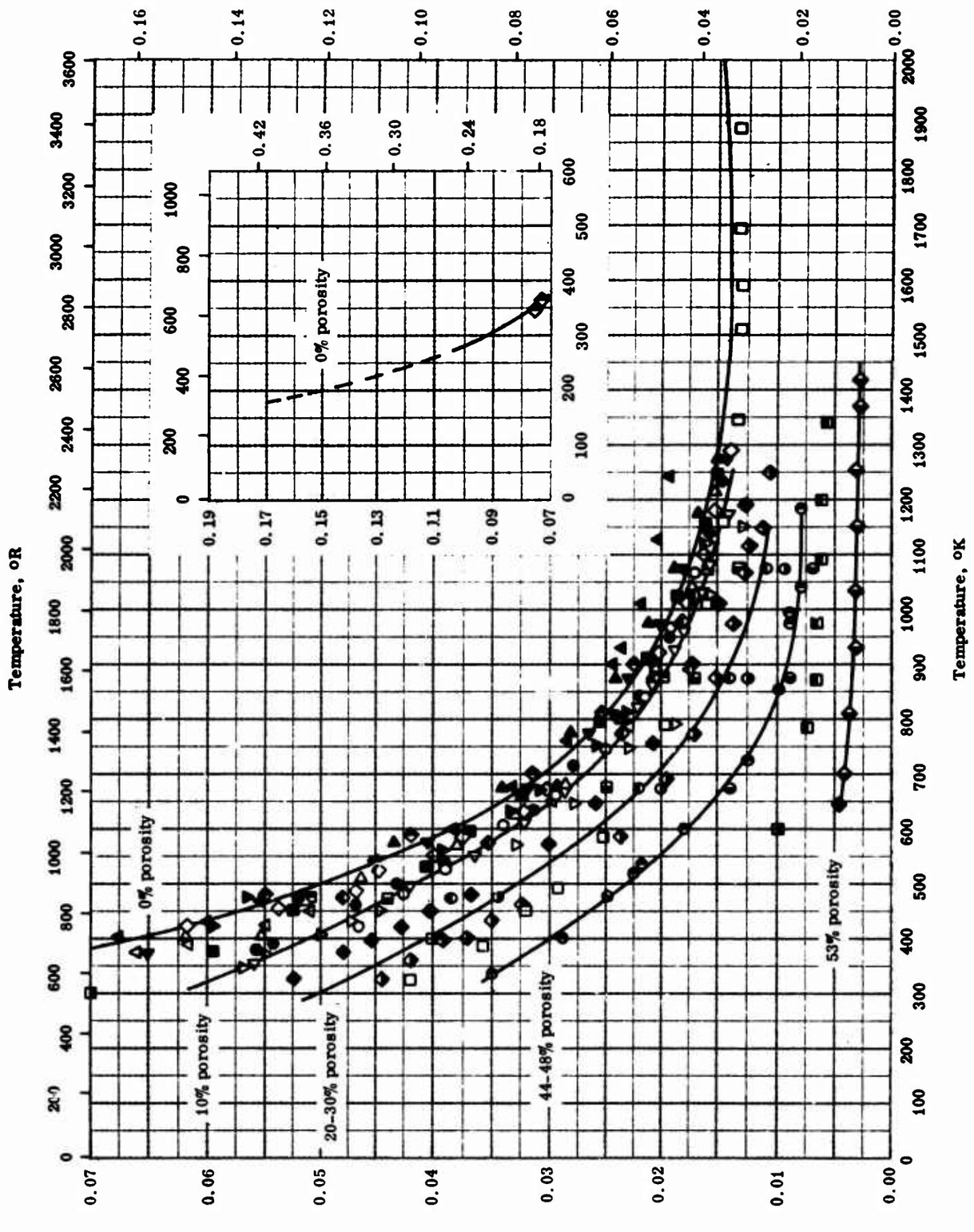
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	47-4	273-1173	0.2	Corundum, synthetic sapphire; 0.02 - 0.03 impurities, mostly SiO_2, $\alpha - Al_2O_3$.	
□	53-10	10-1200	0.2	Corundum, synthetic sapphire; 0.01 - 0.02 impurities.	
△	56-7	10-1200		Corundum, synthetic sapphire; 99.98 Al_2O_3, 0.005 each Fe and Si, and 0.002 Cr; $\alpha - Al_2O_3$.	
◇	50-7	20-300		Synthetic sapphire; 0.02 SiO_2.	Crushed in punch press with stainless steel die.
▷	45-1	298-1800	0.40	100 Al_2O_3; almost colorless sapphire; natural.	
▽	62-6 also 60-14	533-1922	≤5.0	Synthetic sapphire; 100 Al_2O_3; single crystal, density 233 lb ft^{-3}.	
◁	58-7, 59-5, also 59-7	435-1880	0.66-2.9	Polycrystalline Al_2O_3.	Under helium atm.
●	58-7, 59-5, also 59-7	533-1228	0.66-2.9	Synthetic sapphire.	Under helium atm.
■	60-17	533-1228	0.7-2.9	Synthetic sapphire.	Under helium atm.

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SPECIFIC HEAT -- ALUMINUM OXIDE (continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▲	61-12	1273-2273	1.3	Synthetic sapphire.	
◆	63-13	552-1385		Synthetic sapphire.	
▼	63-16	1300-2000	≤3.0	98.7 Al_2O_3 and 1.0 SiO_2.	Sintered; under argon atm.
▶	60-15	325-987	0.5	Corundum; 0.0013 Cr, 0.001 Fe, 0.001 Mo and 0.000 Cu.	
⊖	60-16	1089-1700		Synthetic sapphire; essentially pure.	



THERMAL CONDUCTIVITY -- ALUMINUM OXIDE

THERMAL CONDUCTIVITY -- ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
■	63-10	300-600		Lucalox from General Electric Co.; 99.9 pure α - Al_2O_3; polycrystal; gas tight, essentially zero porosity; density 3.98 g cm^{-3}.	
○	60-4	419-1067		AP - 30 from McDonel Refractory Porcelain Co.; 99.5 Al_2O_3; 25.69% porosity and 2.95 g cm^{-3} bulk density.	
□	58-7	323-1876		Polycrystal.	
△	59-1	373-1128	±4	0.30 vol.% Cr_2O_3; total porosity 17.2%.	Prepared by calcined Cr_2O_3 and Al_2O_3 in a water suspension and either slip-cast or hydrostatically pressed; fired at 1800 C.
▽	59-1	348-1150	±4	1.26 vol. % Cr_2O_3; total porosity 19.8 %.	Same as above.
◁	60-5	354-1171		Gulton HSB Alumina; 99.3 Al_2O_3, 0.23 Fe_2O_3, 0.22 SiO_2, 0.05 C, 0.05 CaO, 0.05 TiO_2, 0.02 MgO, 0.01 Na_2O, and 0.07 others; polycrystal with average grain dia 2 μ; density 3.86 g cm^{-3} and 2.6% porosity. [Author's design.: No. 1]	Hot-pressed and heat-treated; impurity analysis made after heat-treated.
▷	60-5	403-1213		Same as above; average grain dia 3 μ; density 3.90 g cm^{-3} and porosity 1.5%. [Author's design.: No.2]	
◇	60-5	423-1292		Same as above; average grain dia 6 μ after heat-treatment; density 3.84 g cm^{-3} and porosity 3.0%. [Author design.: No.3]	The above sample heat-treated for 100 hrs at 1500 C.
●	60-5	379-1234		Same as above; average grain dia 4 μ; density 3.90 g cm^{-3} and porosity 1.6%. [Author's design.: No. 4]	

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REFERENCE INFORMATION

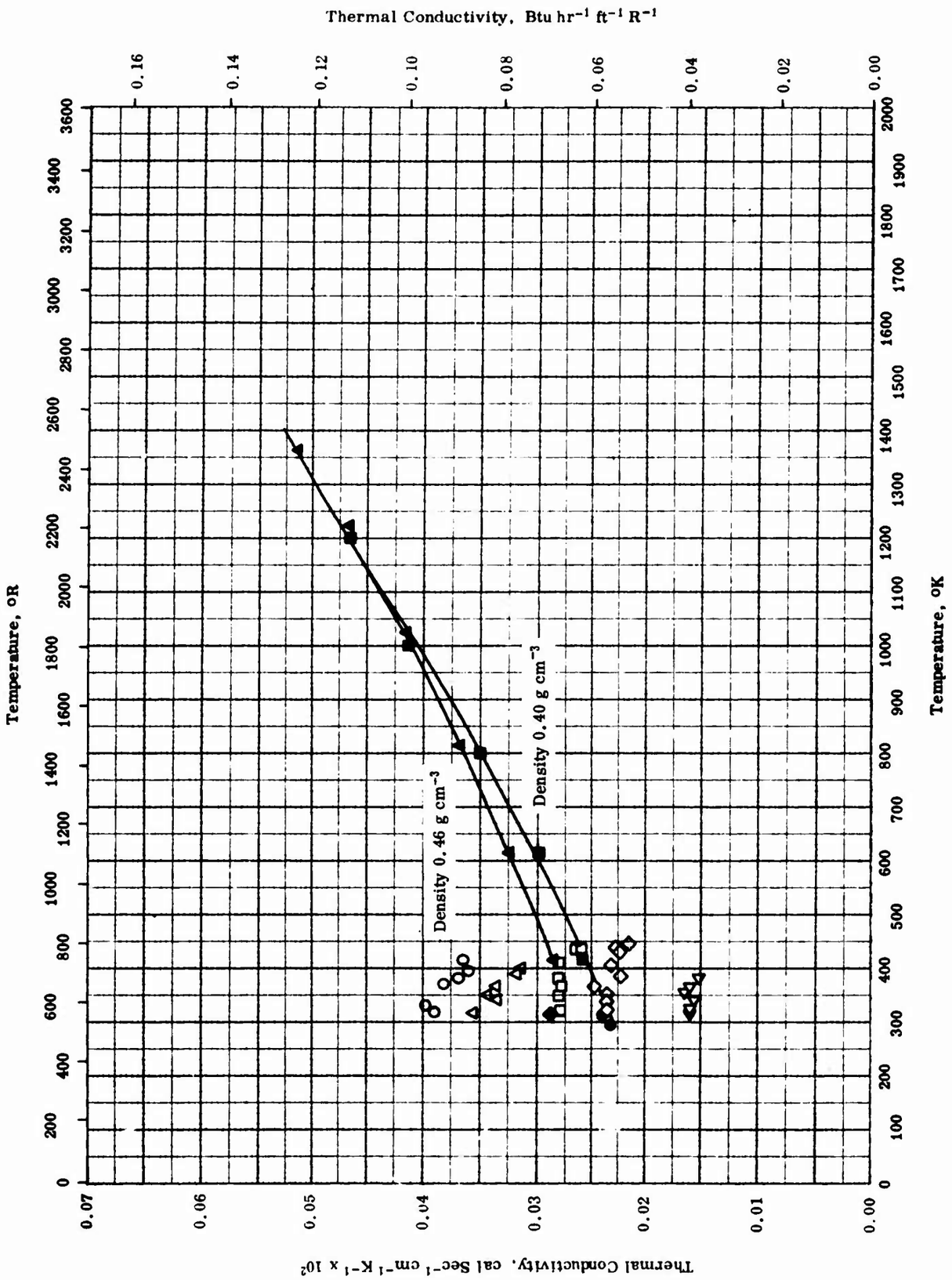
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
■	60-5	376-1243		Same as above; average grain dia 10 μ; density 3.91 g cm^{-3} and porosity 1.4%. [Author's design.: No. 5]	
▲	60-5	403-1241		Norton H.P. Alundun; 99.5 Al_2O_3, 0.40 MgO, 0.05 C, 0.01 SiO_2, 0.01 Fe_2O_3, 0.01 CaO, 0.01 Na_2O, and 0.05 others; polycrystal with average grain dia 3 μ; density 3.97 g cm^{-3} and zero porosity.	Hot-pressed and heat-treated; impurity analysis made after heat treatment.
▼	60-5	371-1243		Same as above; average grain dia 5 μ; density 3.83 g cm^{-3} and porosity 3.3%.	The above sample heat-treated for 100 hrs at 1500 C.
▶	60-5	373-1273		Norton 38-900; 99.8 Al_2O_3, 0.05 Fe_2O_3, 0.05 Na_2O, 0.05 C, 0.03 CaO, 0.02 SiO_2, 0.01 MgO, and 0.04 others; polycrystal with average grain dia 10-11 μ; density 3.89 g cm^{-3} and porosity 1.8%.	Hot-pressed; data corrected to theoretical density.
◀	60-5	373-1273		Norton 38-900 + 1/2% MgO; 99.3 Al_2O_3, 0.44 MgO, 0.05 Fe_2O_3, 0.05 C, 0.05 Na_2O, 0.03 CaO, 0.02 SiO_2, and 0.04 others; polycrystal with average grain dia 8-9 μ; density 3.92 g cm^{-3} and porosity 1.1%.	Hot-pressed; data corrected to theoretical density.
◆	59-1	325-1193	±4	Solid solution with 2.88 Cr_2O_3 by vol; polycrystal; total porosity 20.1%.	Prepared by mixing calcined Cr_2O_3 and Al_2O_3 in a water suspension and by slip-casting or hydrodynamically pressed; fired at 1800 C; data corrected to theoretical density.
◆	59-1	323-1249	±4	Solid solution with 6.42 Cr_2O_3 by vol.; total porosity 22.1%.	Same as above.

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THERMAL CONDUCTIVITY -- ALUMINUM OXIDE (continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◆	58-7	473-973	3	Wesgo Al-300; 97.6 Al_2O_3.	Ground and polished on diamond laps.
◆	58-6	347-900		Norton 38-900; grain size distribution ranging from 5-9 microns with a peak at 7.5 microns.	Hot-pressed.
◆	49-1	645-1422		99^+ pure; density 120 lb ft^{-3} and porosity 53%.	Made from 8 mesh grain or finer; fired at 3690 R.
■	49-1	783-1256		99^+ pure; density 195 lb ft^{-3} and porosity 23%.	Made from 14 mesh grain or finer; fired at 3690 R.
■	54-9	473-1073		Zero porosity.	Ground in steel mill and acid treated to remove Fe; pores formed by casting with napthalene flakes and evaporating napthalene; prepared from Norton Co. Alundum abrasive grain 38 x 220 F.
◘	54-9	473-1073		Porosity 12.3%, with spherical isometric pores.	Same as above.
◓	54-9	473-1073		Porosity 23.4%, with spherical isometric pores.	Same as above.
◒	54-9	473-1073		Porosity 30.0%, with spherical isometric pores.	Same as above.
◐	54-9	473-1073		Porosity 44.2%, with spherical isometric pores.	Same as above.
◑	54-9	333-1183		Porosity 48.7%, with spherical isometric pores.	Same as above.



THERMAL CONDUCTIVITY -- ALUMINUM OXIDE POWDER

THERMAL CONDUCTIVITY -- ALUMINUM OXIDE POWDER

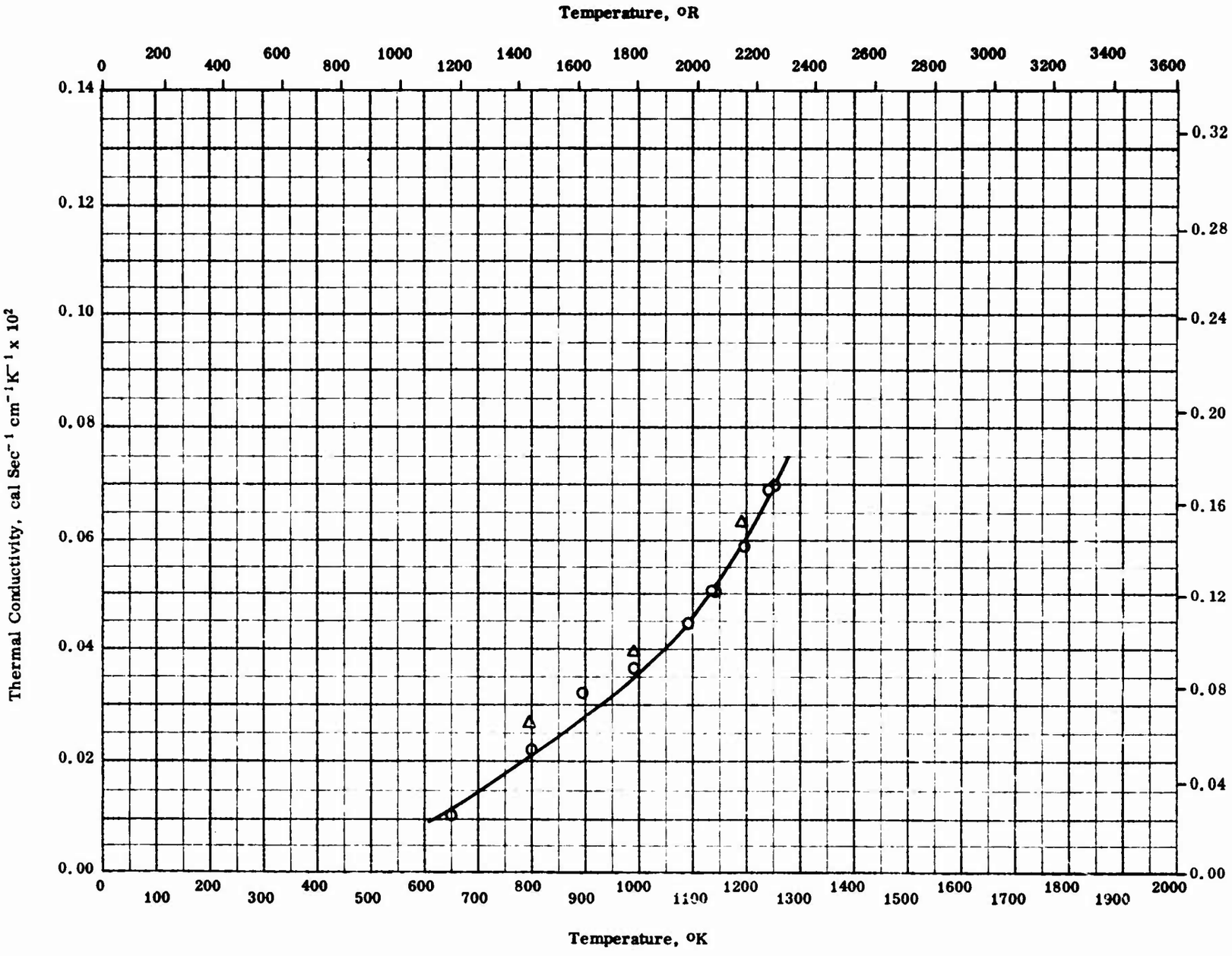
REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-8	318-417	5	α-monohydrate (bohmite) structure; true density 2.45 g cm^{-3}; B. E. T. surface area 362 m^2g^{-1}, pore volume 0.475 cm^3g^{-1}; particle size distribution: 90 microns 61.0% through, 60 32.5%, 45 23.5%, 20 11.5%, and 10 7.0%; pellet density 1.211 g cm^{-3} with micro pore vol. 0.365 cm^3g^{-1}, macro pore vol. 0.120 cm^3g^{-1}, micro void fraction 0.409, and macro void fraction 0.134.	Prepared from the spray-dried alumina powder supplied by the American Cyanamid Co.; dried at 500 F for 24 hrs and pelleted while hot; drying loss 16.4 wt. % at 500 F and 27.0 wt. % at 1800 F; measured in vacuum.
△	62-8	315-400	5	Same as above; pellet density 1.010 g cm^{-3} with micro pore vol. 0.383 cm^3g^{-1}, macro pore vol. 0.198 cm^3g^{-1}, micro void fraction 0.387, and macro void fraction 0.200.	Same as above.
□	62-8	322-437	5	Same as above; pellet density 0.896 g cm^{-3} with micro pore vol. 0.400 cm^3g^{-1}, macro pore vol. 0.308 cm^3g^{-1}, micro void fraction 0.359, and macro void fraction 0.275.	Same as above.
◇	62-8	318-441	5	Same as above; pellet density 0.785 g cm^{-3} with micro pore vol. 0.416 cm^3g^{-1}, macro pore vol. 0.451 cm^3g^{-1}, micro void fraction 0.327, and macro void fraction 0.353.	Same as above.
◁	62-8	318-378	5	Same as above; pellet density 0.672 g cm^{-3} with micro pore vol. 0.434 cm^3g^{-1}, macro pore vol. 0.670 cm^3g^{-1}, micro void fraction 0.275, and macro void fraction 0.450.	Same as above.
●	63-8	293-313	<2	Powdered form; density 0.41 g cm^{-3}.	Produced at NBS by ignition of hydrated aluminum chloride in a muffle furnace at 1150 C.

(Continued onto next page)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◆	63-8	313	<2	Same as above; density 0.46 g cm^{-3}.	Same as above.
▲	63-8	413-1363	<3	Same as above; density 0.44 g cm^{-3}.	Same as above.
■	63-8	413-1198	<3	Same as above; density 0.40 g cm^{-3}.	Same as above.



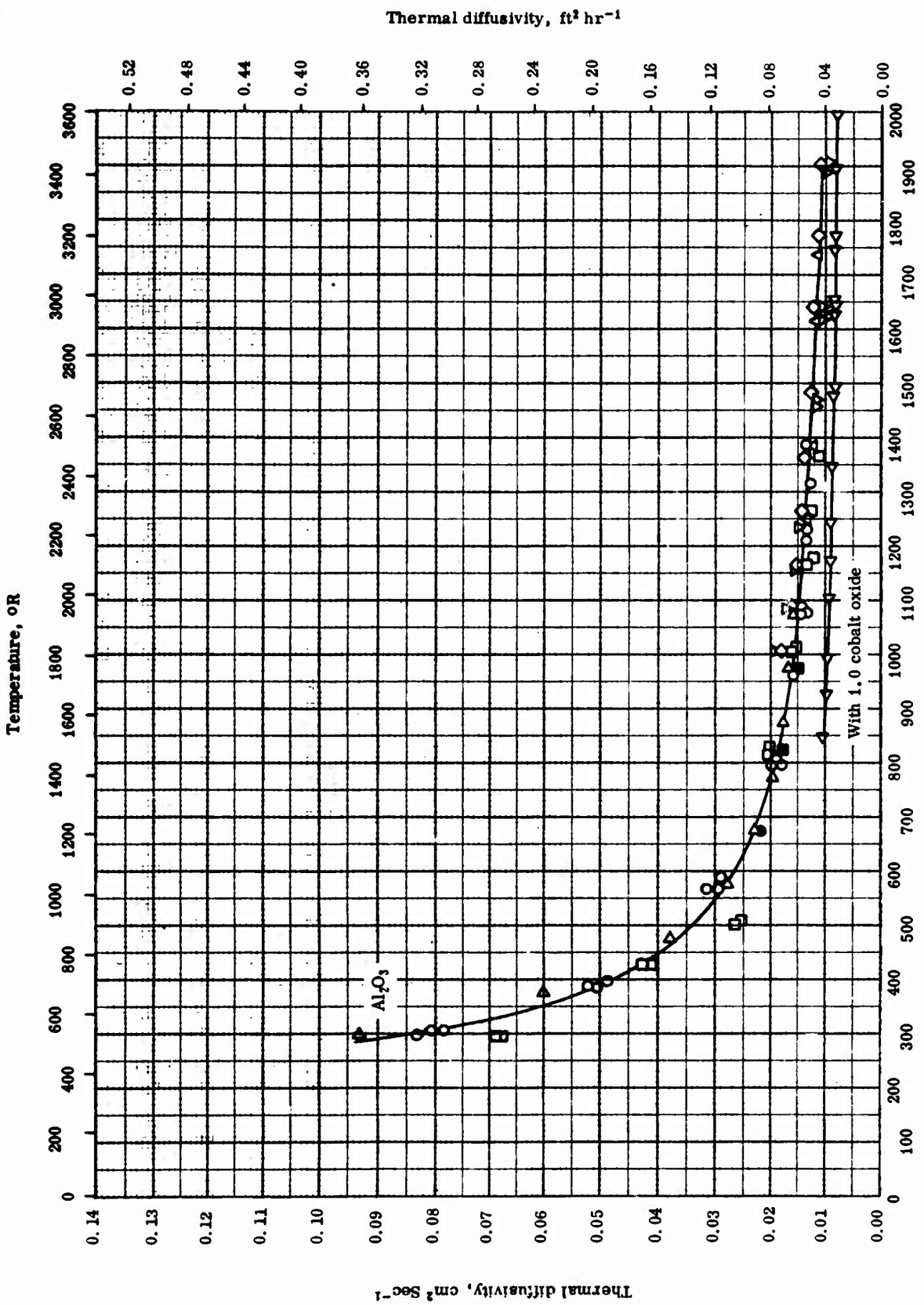
THERMAL CONDUCTIVITY -- ALUMINUM OXIDE FOAM

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THERMAL CONDUCTIVITY -- ALUMINUM OXIDE FOAM

REFERENCE INFORMATION

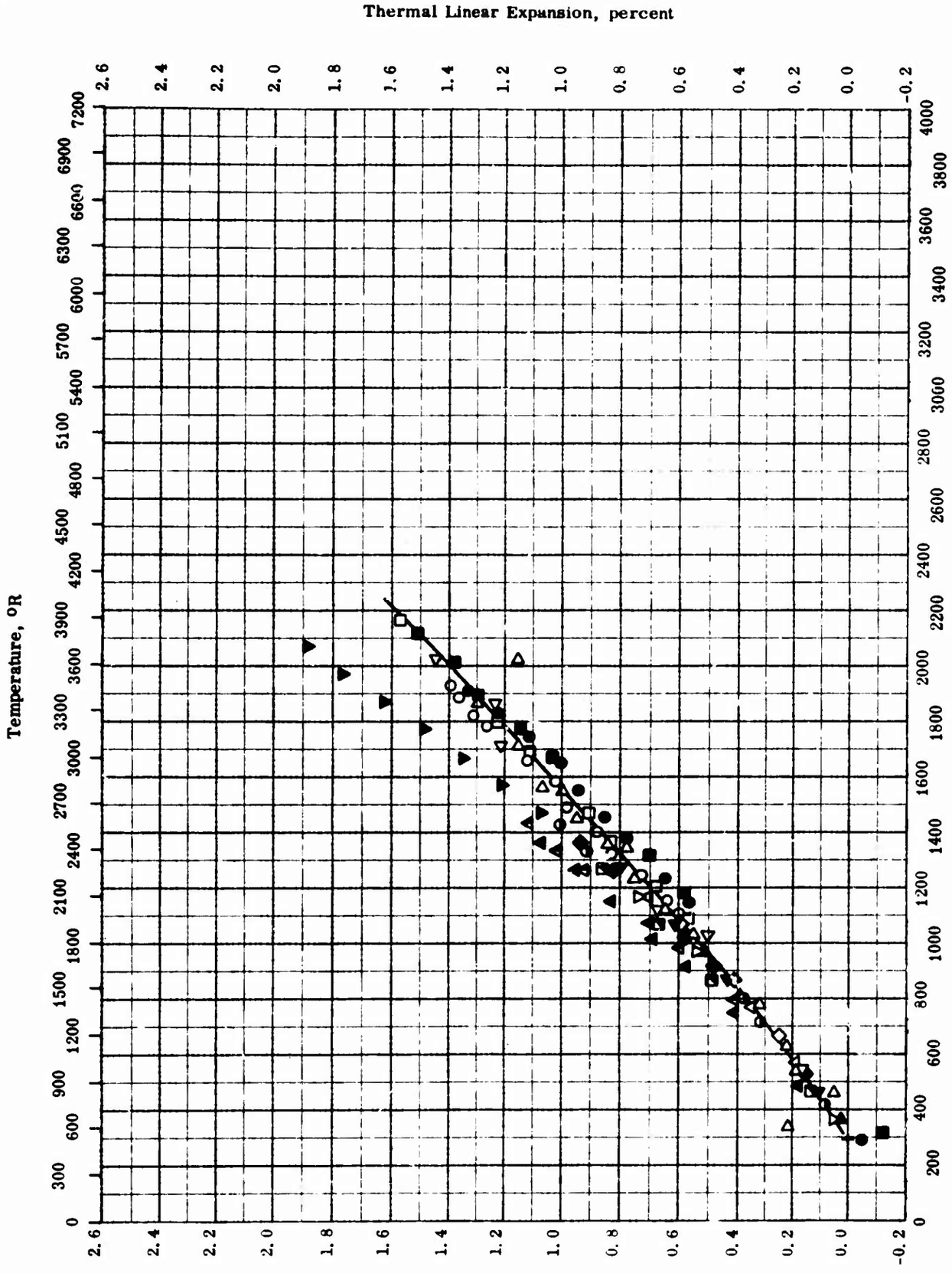
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-12	650-1250		Foam density 29.6 lb ft^{-3}.	Measured in 4×10^{-7} to 2×10^{-4} mm Hg pressure range.
Δ	63-12	794-1189		Same as above.	Measured when cooled.



THERMAL DIFFUSIVITY -- ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
●	50-1	673		True density 4.0 g cm^{-3}; 10% open pores and 13% total pores.	Cast from acid suspensions of finely ground material and fired at 1760 C for 2 hrs.
■	50-1	673-973		True density 4.0 g cm^{-3}; 5% total pores and no open pores.	Same as the above sample except fired at 1790 C for 2 hrs and 1815 C for 5 hrs.
▲	50-1	673-973		Same description as the above sample except containing 0.2% open pores.	Same as above.
▼	50-1	673-973		True density 4.0 g cm^{-3}; 5% total pores and no open pores.	Same as above except fired at 1815 C for 5 hrs.
○	63-1	298-1388		Pure; density 3.834 g cm^{-3}	Extruded.
□	63-1	293-1368		Pure; density 3.914 g cm^{-3}	Pressed.
◇	63-2	1005-1903	±5 - ±10	GD-10; purity unknown; sample appearing not at all homogeneous and containing voids; density 3.85 g cm^{-3}; from Corning	
△	63-2	996-1906	±5 - ±10	FS-54; purity unknown; same description as the above sample.	
▽	63-2	298-1908	±5 - ±10	AD-995 Coor high purity alumina; 99.5 Al_2O_3; sample appearing to be quite dense and homogeneous; density 3.86 g cm^{-3}.	
◁	63-2	848-1998	±5 - ±10	AP 35 McDanel alumina; 99.0 pure with 1.0 cobalt oxide; density 2.94 g cm^{-3}.	Fired after mixing with 1.0 additional of cobalt oxide.
▷	62-1	298-1273	15	Density 3.04 g cm^{-3}.	



THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE

THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◀	60-36	299-1273		Pure Al_2O_3.	Ball-milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15% binder (40 g Carbowax 20 M, 20 cc of 2% methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired to 1500 C for 17 hrs, cooled to room temperature in less than 30 min , and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
◪	60-36	299-1273		Same as above.	Same as above except measured along c-axis.
◇	63-34	293-1273		Fabricated from Linde Type B polishing alumina with purity >99.9 Al_2O_3; 99.5% theoretical density; dimensions 2 in. diameter by 1/4 in. thick.	Hot pressed with restraining pressure of 100 psi maintained until temperature of 1000 C was reached, increased gradually to final pressure of 6000 psi and temperature of 1500 C, held at final pressure 4 hrs, and cooled overnight; measured in air atm.
△	63-35	298-1275		Prepared from commercial single-crystal Al_2O_3 rods.	Matured at 1000 C and held overnight, heated to 1200 C for 1 hr, and then desiccated; heating rate approx. 5 C min^{-1}; measured along orientation approx. 60 degrees from c-axis.

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THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE (continued)

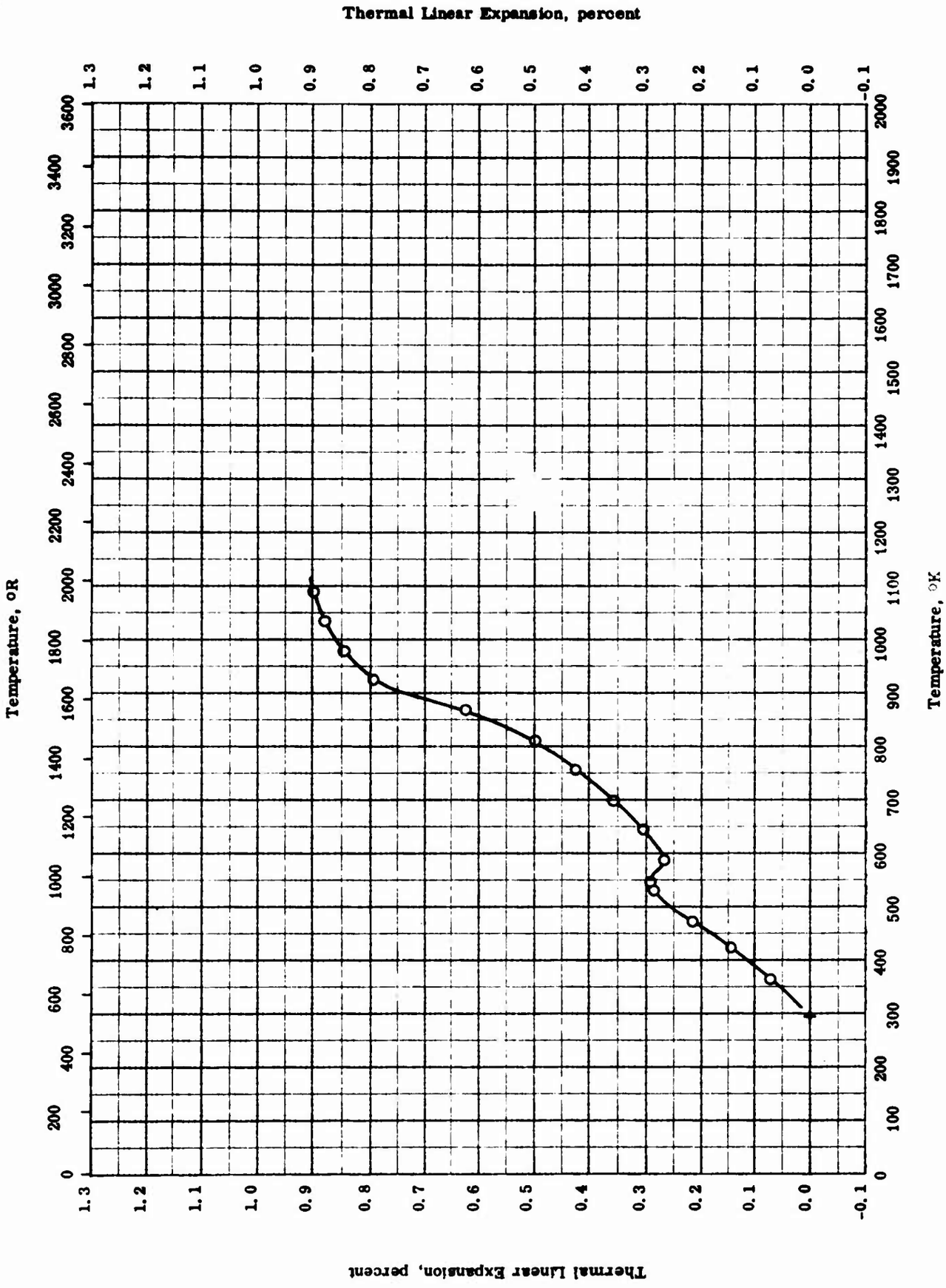
REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▽	63-10	298-1253		Lucalox (α-Al_2O_3); 99.9 pure; polycrystalline; density 3.98 g cm^{-3}; almost zero porosity; melting point 2040 C.	Prepared by pressing fine grain, high purity Al_2O_3 at room temperature and firing; expansion is uniform in all directions.
▷	58-21	293-2023		Al_2O_3, Norton Co.; polycrystalline; bulk density 3.83 g cm^{-3}; average grain size 17 μ; dimensions 1/4 x 1-1/2 x 1/8 in.	Measured along a-axis; two points near room temperature have large unexplained deviation.
◁	58-21	293-2023		Same as above.	Same as above except measured along c-axis.
●	61-39	301-1438	<3	Alpha alumina, Norton Co.; spectrographic analysis 0.03> Si, 0.03> Na, 0.02> V, 0.01 Ca, 0.01> Fe, 0.008> Zr, 0.006 Ti, 0.005> Cu, 0.003> Mg, and 0.001> Mn.	Pressed and fired at 1200 C in an oxidizing atm lab furnace, cooled, ground flat, and placed in diffractometer furnace; measured along a-axis with K_α radiation.
▲	61-39	301-1438	<3	Same as above.	Same as above except measured along c-axis.
◆	61-39	299-1361	<3	Natural corundum; spectrographic analysis 5> Si, 2> Fe, 1> Cr, 1> Ti, 0.2> V, 0.2> Cu, 0.04> Pb, 0.02> Mg, 0.02> Zr, 0.02> Ca, 0.02> Sn, and 0.01> Mn.	-325 mesh natural corundum powder was coated uniformly on surface of alumina block before measurement; x-ray method; measured along a-axis.
▲	61-39	299-1361	<3	Same as above.	Same as above except measured along c-axis.
▼	63-36	293-2073		99.7 Al_2O_3; prepared from commercial alumina grade G-1; dimensions 4 by 4 by 20 mm; bulk density 3.83 g cm^{-3}; apparent porosity 1.7%. [Author's design : Body 1]	Calcined at 1450 C, ball-milled, HCl washed to remove iron, pressed at 500 kg cm^{-2}, and fired at 1730 C; rate of temperature rise 5 - 8 C min^{-1}; measured in vacuum furnace; authors reported average coefficients.

(Continued onto next page)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specification	Remarks
▶	64-17	298-1273		Polycrystalline; dimensions 1/4 in. diameter x 4 in. long.	Prepared from calcined alumina, wet milled for 24 hrs with 4500 g of 1 in. diameter alumina balls in 5-1/2 qt. alumina mills, dried to 200 C, formed into pressing granules using organic binder, dry pressed, fired to 1650 C with average heating rate of 100 C hr^{-1}, soaked for 3 hrs, and cooled with average rate of about 100 C hr^{-1}.
○	58-20	293-1933		Density 3.83 g cm^{-3}; average grain size 17 microns. [Author's design : Sample No. AY-1]	Cold pressed and sintered in oxidizing atm at 1750 C, measured in argon atm.
●	58-20	293-1933		Same as above.	Cooling cycle for above sample.
□	58-20	298-2163		Single crystal; density 3.98 g cm^{-3}. [Author's design : Sample No. AQ-1]	Measured in argon atm.
■	58-20	318-2163		Same as above.	Cooling cycle for above sample.

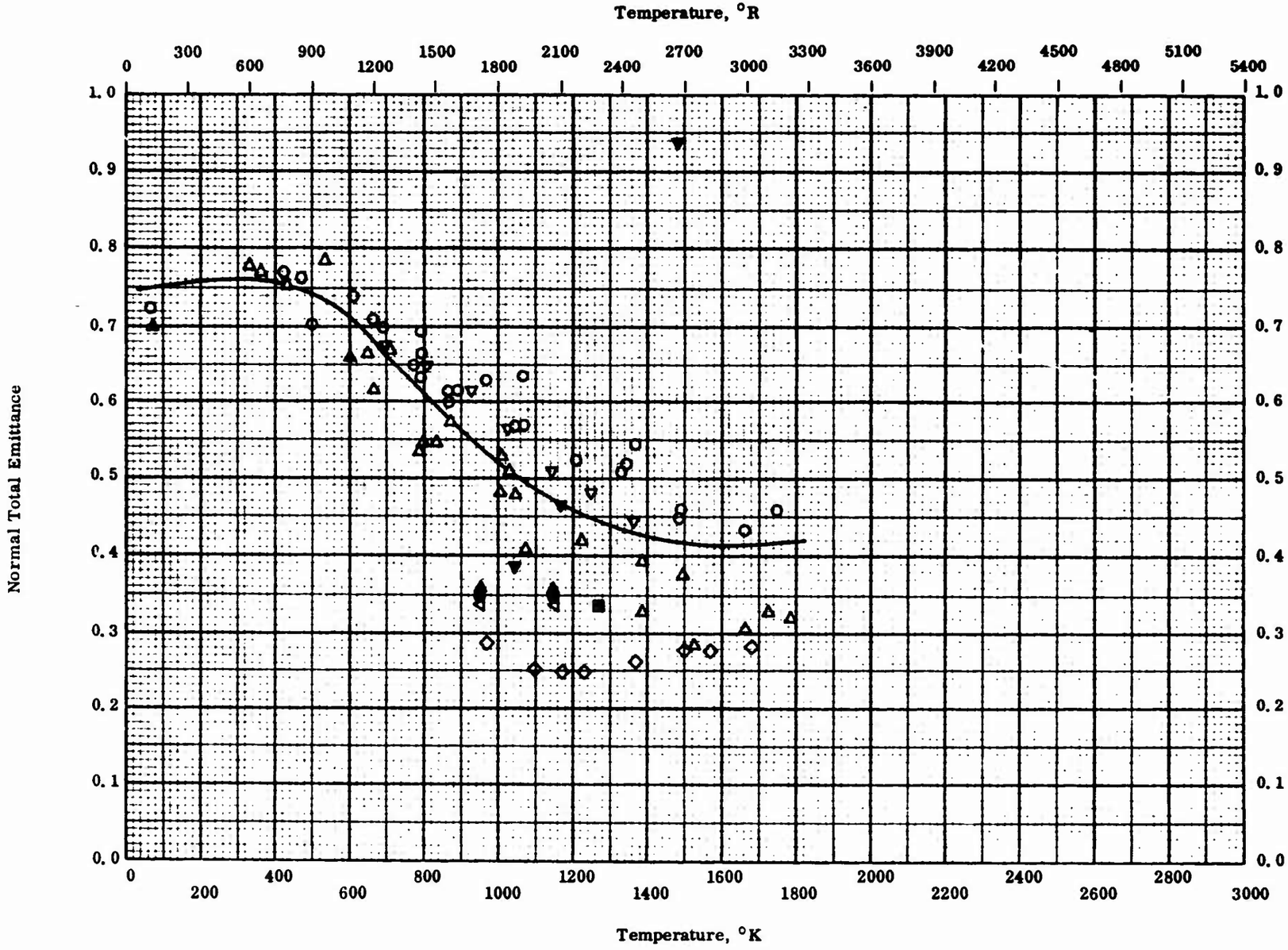


THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE FOAM

THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE FOAM

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	62-30	293-1089		35 - 40 alumina hydrate, 25 - 30 Al_2O_3, 22 - 27 H_3PO_4 (85%), 8 - 12 H_2O, 1 - 1.5 carbon powder, and 0.05 - 0.1 Al powder; density 58 lb ft^{-3}; dimensions 2 in. long by 1/4 in. square.	Cured by immediately placing in 200 F environment; temperature raised to 600 F over 20 hr period and held for 12 hrs; reference temperature not given, assumed to be 68 F.



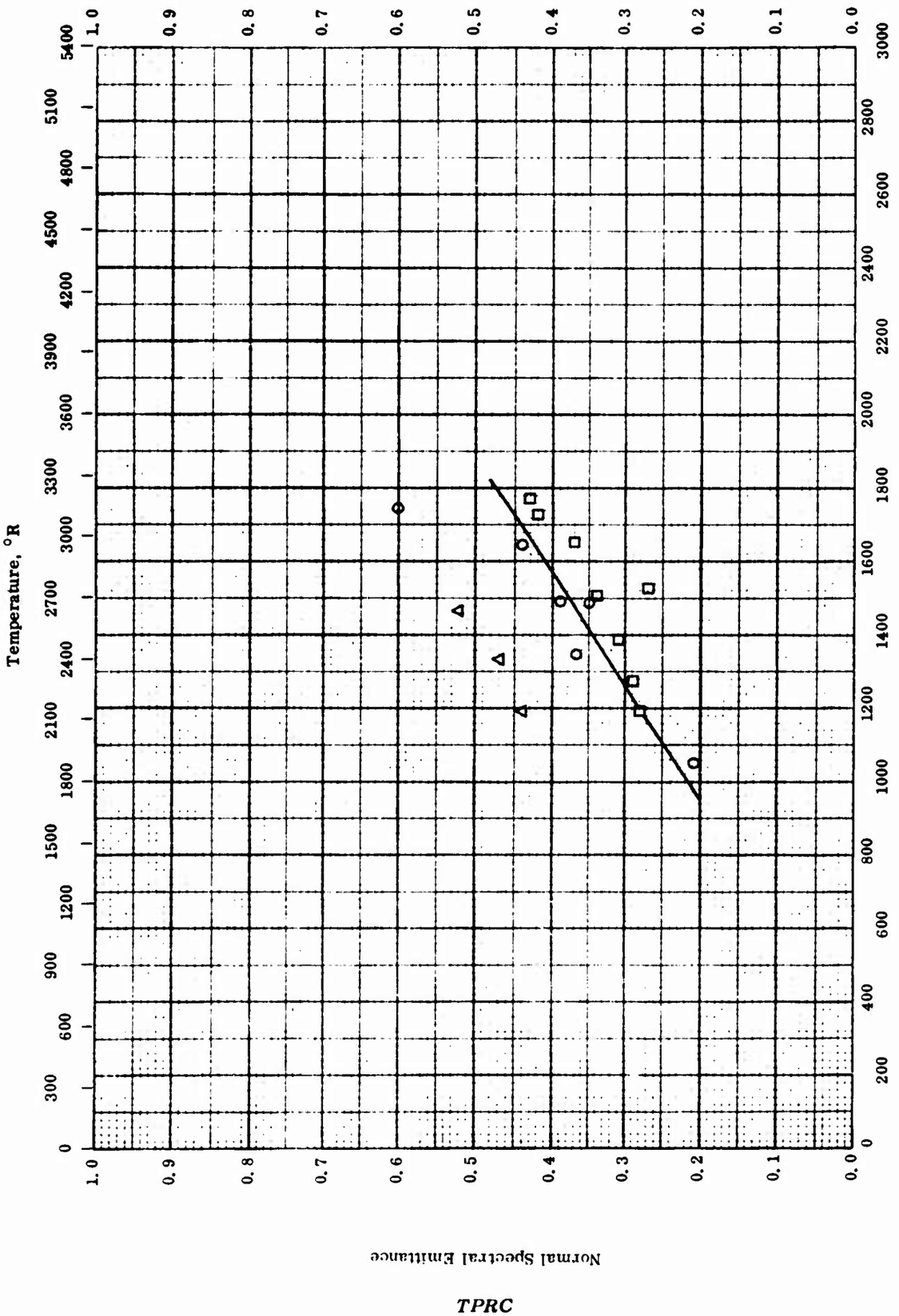
NORMAL TOTAL EMITTANCE -- ALUMINUM OXIDE

TPRC

NORMAL TOTAL EMITTANCE -- ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	59-15	66-1755		Al_2O_3, Norton LA603.	Measured in air.
△	59-15	72-1783		Al_2O_3, Norton RA4213.	Measured in air.
■	63-26	1273	±8	Al_2O_3, pure; 0.032 in. thickness; density 3.35 g cm^{-3}.	Sintered at 2123 K for 2 hrs; measured in argon atmosphere; computed from spectral data.
◁	64-11	958-1158		Al_2O_3, 9.7% porosity.	
▲	64-11	958-1158		Al_2O_3, surface roughness >200 μ in.	
●	64-11	958-1158		Same as above; surface roughness <20 μ in.	
◇	55-6	973-1683	20	Al_2O_3, formed from dense alumina.	Measured in vacuum; average value from different methods.
▽	59-13	700-1366		Al_2O_3, coating on sandblasted and oxidized Inconel strip.	Flame-sprayed.
▼	61-30	1044-1482		Al_2O_3, polycrystalline.	Cleaned; measured in vacuum at 10^{-5} mm Hg.

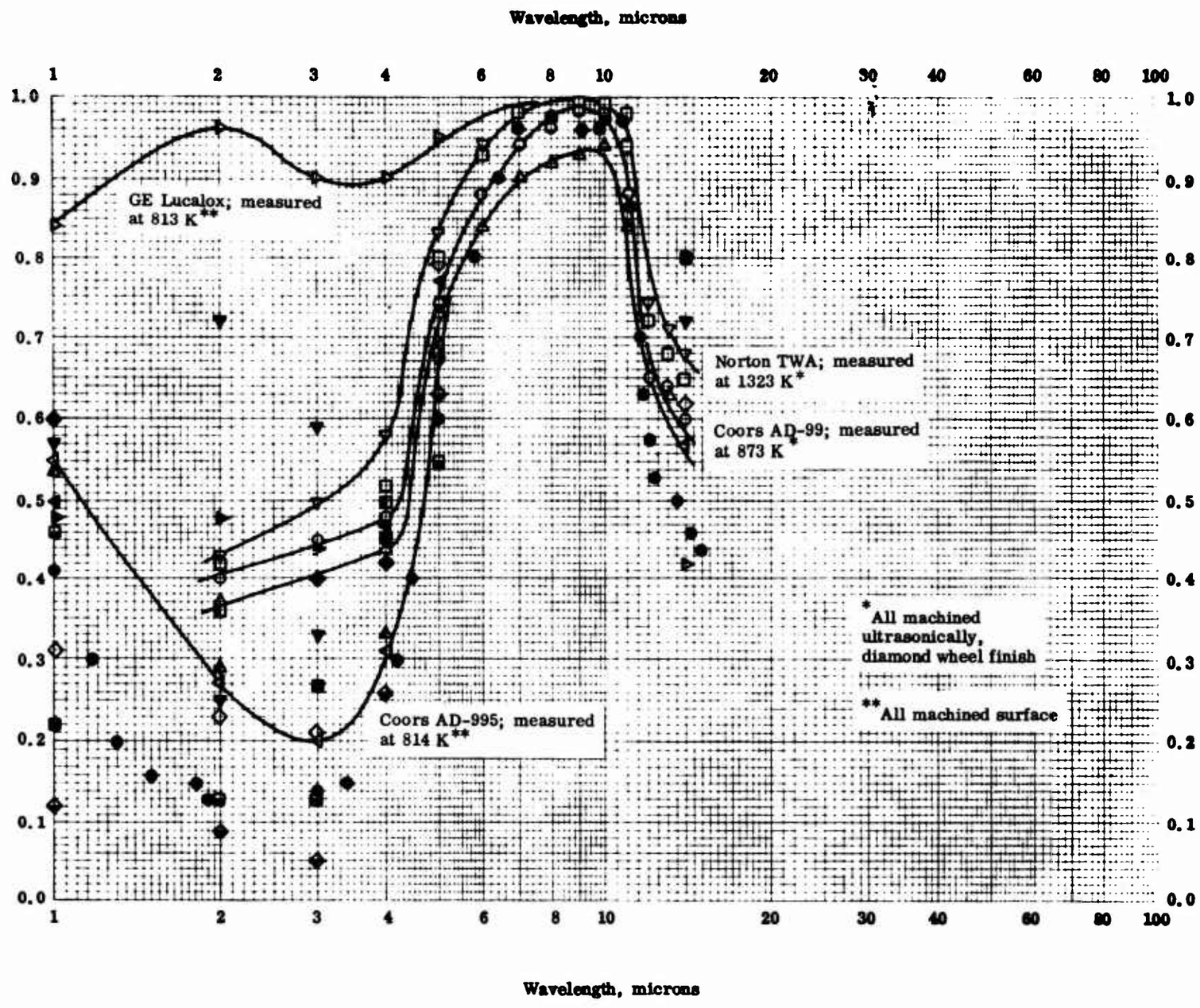


NORMAL SPECTRAL EMITTANCE -- ALUMINUM OXIDE

NORMAL SPECTRAL EMITTANCE -- ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Wavelength μ	Temp. Range °K	Rept. Error%	Sample Specifications	Remarks
○	59-15	0.665	1055-1744		Al_2O_3, Norton LA 603.	Measured in air.
□	59-15	0.665	1194-1778		Al_2O_3, Norton RA 4213.	Same as above.
△	59-15	0.665	1194-1466		Rokide coating on stainless steel.	Same as above.



NORMAL SPECTRAL EMITTANCE -- ALUMINUM OXIDE

NORMAL SPECTRAL EMITTANCE -- ALUMINUM OXIDE

REFERENCE INFORMATION

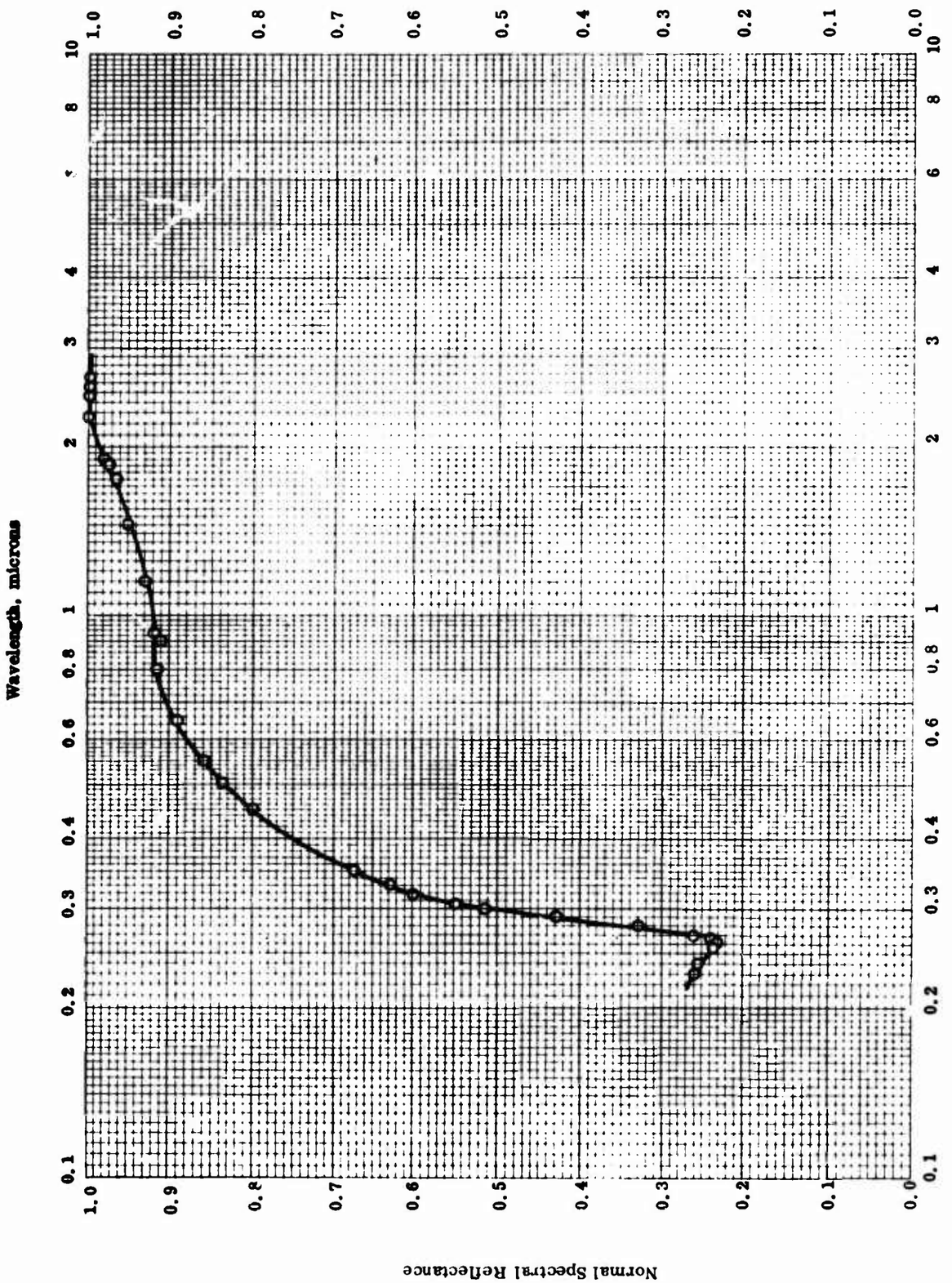
Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
○	60-30	873	2-14	±4	Coors AD-99; 99 pure.	Ultrasonically machined; diamond wheel finish; measured in air.
□	60-30	1303	2-14	±4	Same as above.	Same as above.
△	60-30	873	2-14	±4	Norton TWA No. 2, A402; 98.56 pure.	Same as above.
▽	60-30	1323	2-14	±4	Same as above.	Same as above.
◁	64-12	814	1-14	±5	Coors AD-995; 99.5 pure.	Machined surface.
◇	64-12	1592	1-14	±5	Same as above.	Same as above.
■	64-12	1423	1-14	±5	Coors AD-99; 99 pure.	Same as above.
◆	64-12	822	1-14	±5	Coors AD-96; 96 pure.	Same as above.
▶	64-12	1526	1-14	±5	Same as above.	Same as above.
▼	64-12	1053	1-14	±5	Coors AD-96; 1 $CoCO_3$.	Same as above.
▲	64-12	822	1-14	±5	McDanel AP-35; 99 pure.	Cast; same as above.
▼	64-12	1523	1-14	±5	Same as above.	Same as above.
◀	64-12	1053	1-14	±5	Al_2O_3, McDanel AV 30, vitrified alumina; 96 pure.	Same as above; not cast.
◧	64-12	1592	1-14	±5	Same as above.	Same as above.
◙	64-12	833	1-14	±5	Al_2O_3, McDanel AP-35 (isostatic); 99 pure.	Same as above.
◆	64-12	1572	1-14	±5	Same as above.	Same as above.

(Continued onto next page)

NORMAL SPECTRAL EMITTANCE -- ALUMINUM OXIDE (Continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
▷	64-12	813	1-14	±5	Al_2O_3, GE Lucalox.	Cold pressed and sintered with addition of MgO to control grain growth; machined surface.
●	62-23	1273	1-15		Al_2O_3, pure, 0.032 in. thickness; density 3.35 g cm^{-3}.	Sintered at 2123 K for 2 hrs; measured in argon atmosphere; data taken from a curve.

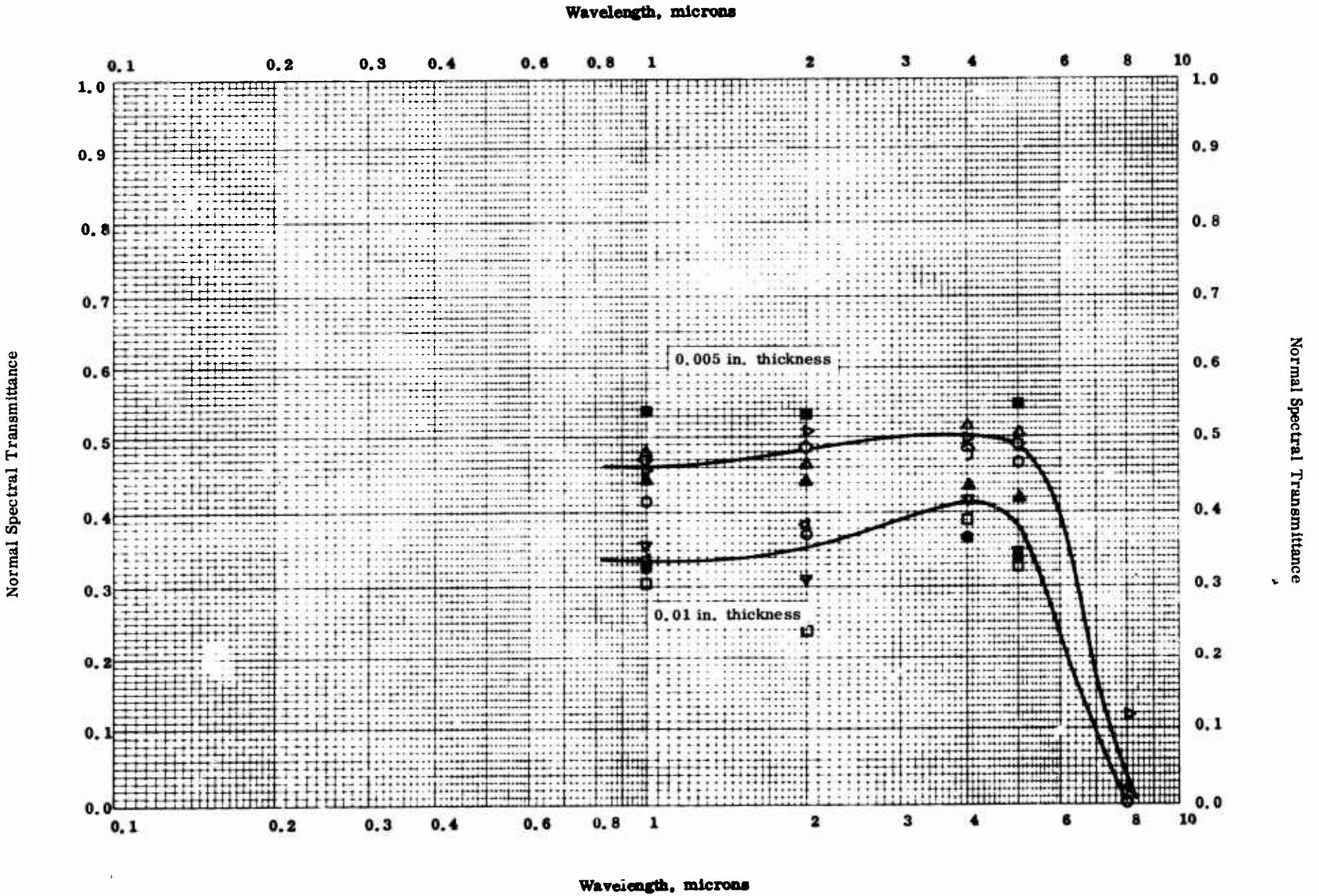


NORMAL SPECTRAL REFLECTANCE -- ALUMINUM OXIDE

NORMAL SPECTRAL REFLECTANCE — ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
O	63-26	298	0.23-2.65	5	Al_2O_3, pure, 0.069 in. thickness; density 3.45 g cm^{-3}.	Sintered at 1923 K for 1 hr; data taken from a curve; MgO as reference standard; normal incidence, hemispherical viewing.



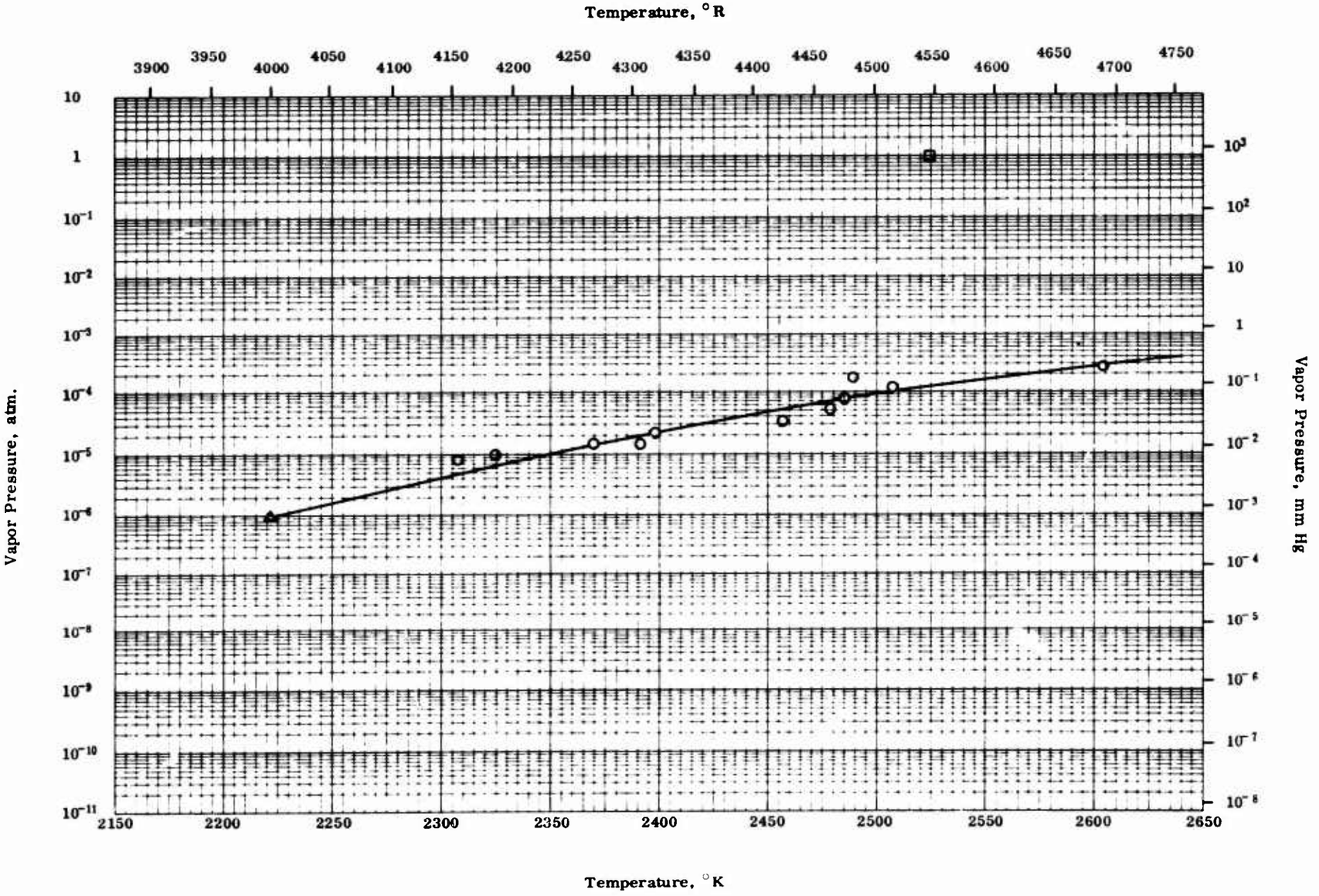
NORMAL SPECTRAL TRANSMITTANCE -- ALUMINUM OXIDE

NORMAL SPECTRAL TRANSMITTANCE -- ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	64-12	298	1-8	±5	Al_2O_3, Coors AD96; 96 Al_2O_3 and 1 $CoCO_3$; 0.005 in. thickness.	
□	64-12	298	1-8	±5	Same as above; 0.01 in. thickness.	
△	64-12	298	1-8	±5	Al_2O_3, McDanel AV30; 96 Al_2O_3; 0.005 in. thickness.	
▽	64-12	298	1-8	±5	Same as above; 0.01 in. thickness.	
◇	64-12	298	1-8	±5	Al_2O_3, McDanel AP35 (No. 3); 99 pure; 0.005 in. thickness.	
●	64-12	298	1-8	±5	Same as above; 0.01 in. thickness.	
▷	64-12	298	1-8	±5	Al_2O_3, McDanel AP35 (No. 4); 99 pure; 0.005 in. thickness.	
◁	64-12	298	1-8	±5	Same as above; 0.01 in. thickness.	
■	64-12	298	1-8	±5	Al_2O_3, Coors AD99; 99 Al_2O_3; 0.005 in. thickness.	
▲	64-12	298	1-8	±5	Same as above; 0.01 in. thickness.	

TPRC



VAPOR PRESSURE -- ALUMINUM OXIDE

VAPOR PRESSURE -- ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	51-5	2309-2605		Al_2O_3.	W cell; author reports pressure of AlO assuming Al_2O_3 (liq) = 2 AlO (gas) + 1/2 O_2 (gas).
□	49-3	2523		Al_2O_3.	
△	52-7	2222		Al_2O_3.	Tested in air.

PROPERTIES OF ALUMINUM OXIDE
(Sapphire)

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	3.73	233
Softening Point	2313	4163

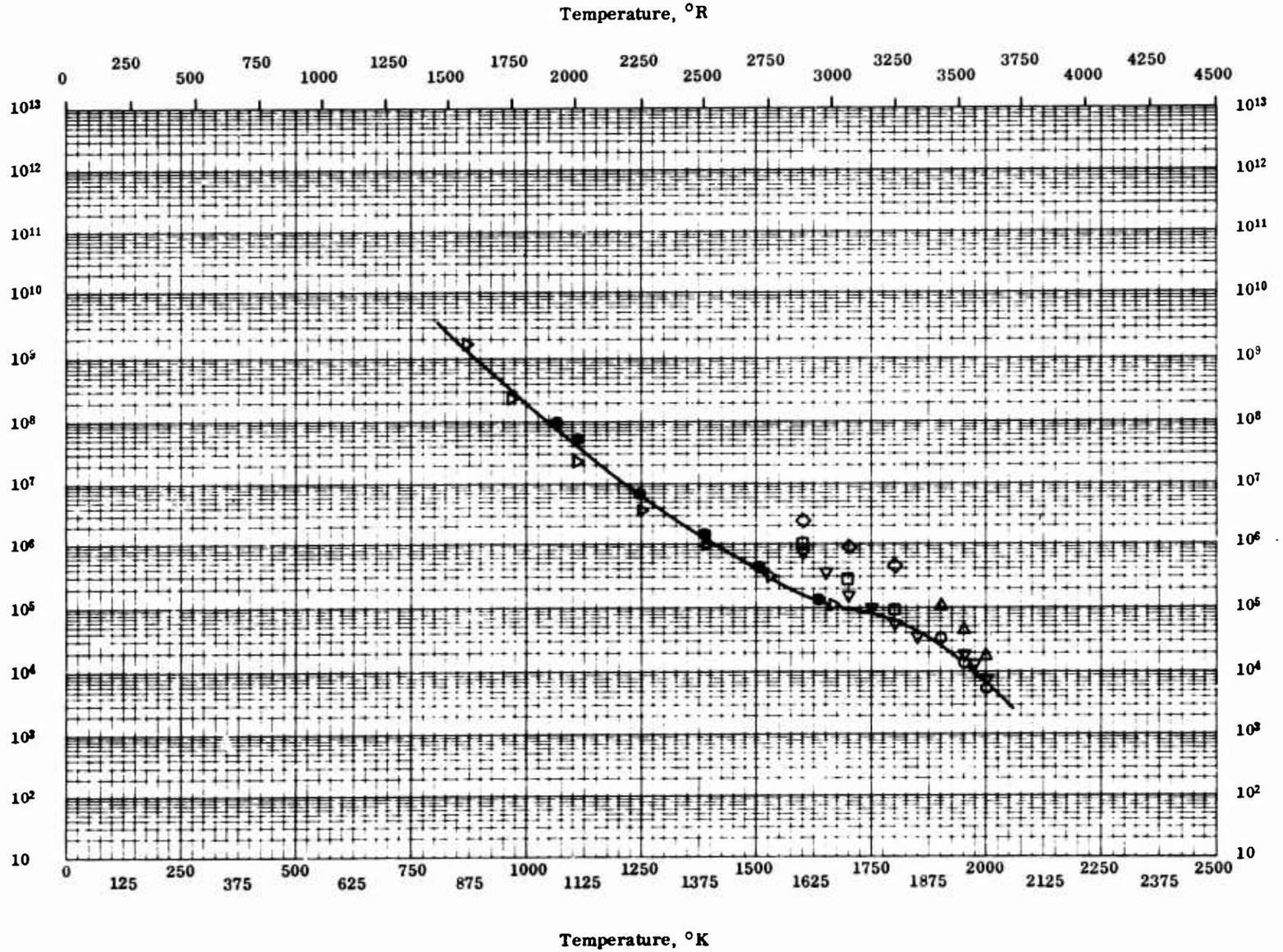
REPORTED VALUES

Density		$g\ cm^{-3}$	$lb\ ft^{-3}$
	□	3.983 ± 0.001	248.65 ± 0.06
	○	3.73	233
Softening Point		K	R
	△	2313	4163
	▽	>1873	>3371
	◇	>1873	>3371

PROPERTIES OF ALUMINUM OXIDE
(Sapphire)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	57-13	298			
○	62-6	298		Synthetic sapphire, 100 Al_2O_3; grown single crystal.	100% theoretical density; max. exposure temp. 3006 F.
△	58-14	2313		100 Al_2O_3, single crystal sapphire.	Softening point.
▽	58-14	>1873		99+ Al_2O_3, same as above.	Same as above.
◇	58-14	>1873		97 Al_2O_3, same as above.	Same as above.



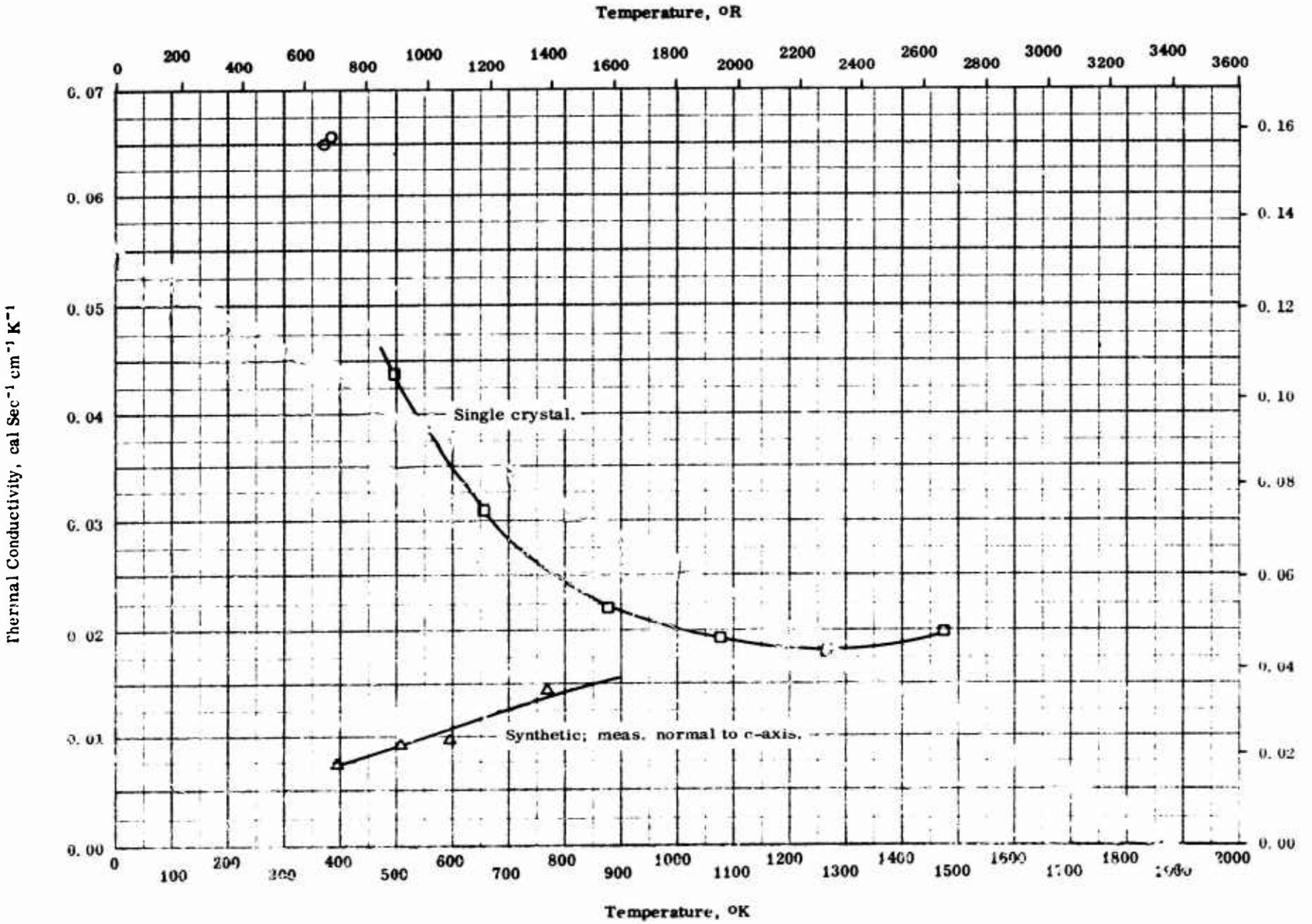
ELECTRICAL RESISTIVITY -- ALUMINUM OXIDE
(Sapphire)

Electrical Resistivity, ohm cm

ELECTRICAL RESISTIVITY -- ALUMINUM OXIDE
(Sapphire)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-22	1900-2000		99.9 Al_2O_3; single crystal.	Boiled in HCl, rinsed with distilled water, and then with acetone; measured with c-axis at an angle of 60 degrees to the rod axis of the sample under 10^{-10} atm O_2 pressure; activation energy 5.8 ev.
□	61-22	1600-1800		Same as above.	Same as above, except activation energy 2.84 ev.
△	61-22	1900-2000		Same as above.	Same as above, except measured under 10^{-5} atm O_2 pressure and activation energy 5.5 ev.
◇	61-22	1600-1800		Same as above.	Same as above, except activation energy 2.62 ev.
▽	61-22	1600-2000		Same as above.	Same as above, except measured under 1.0 atm O_2 pressure and activation energy 2.97 ev; uniform through the temperature range measured.
▷	53-22	873-1667		Sapphire.	Preheated to 1400 C; undeformed.
●	53-22	1070-1667		Sapphire.	Same as above.

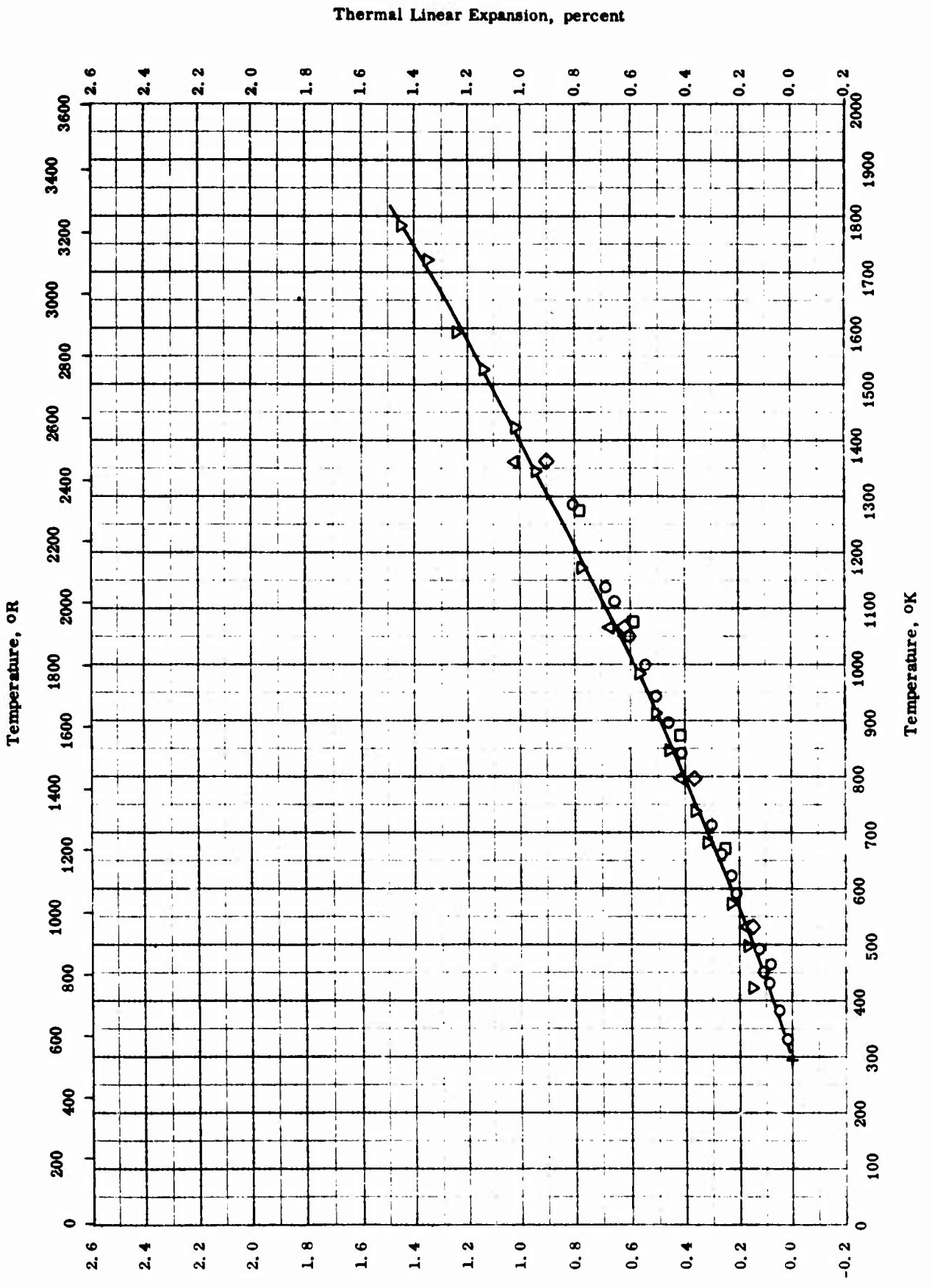


THERMAL CONDUCTIVITY -- ALUMINUM OXIDE
(Sapphire)

THERMAL CONDUCTIVITY -- ALUMINUM OXIDE
(Sapphire)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	52-1	366-373		Synthetic.	Sample axis at 60° from c-axis.
□	57-4	493-1473		Single crystal.	
△	43-1	392-764		Synthetic.	Measured normal to c-axis.

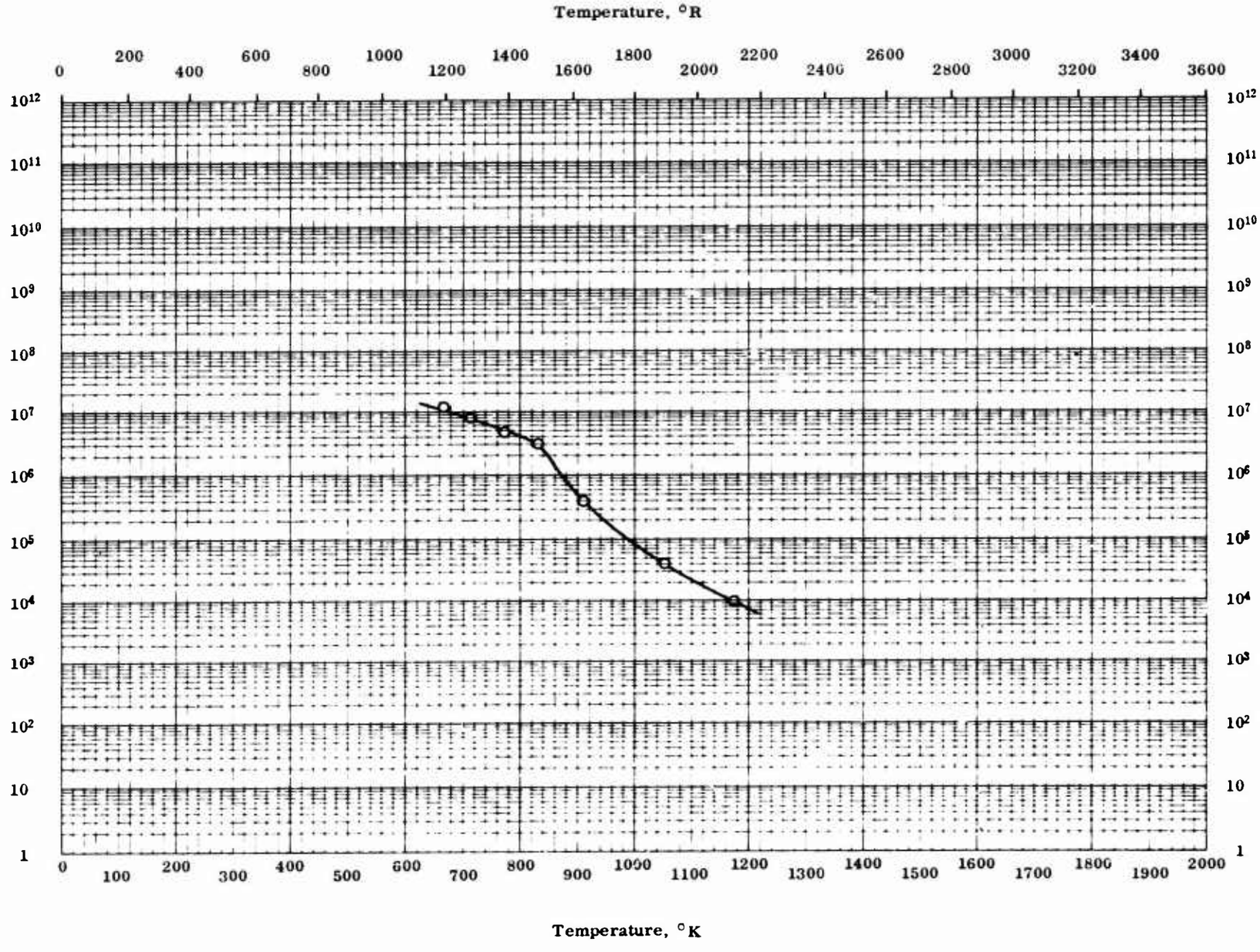


THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE
(Sapphire)

THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE
(Sapphire)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	59-18	293-1255	2	Single crystal; dimensions 4 in. long by 7/16 in ^{2}.	Heating rate 2 C min^{-1}.
□	63-34	293-1273			Measured in air atm along c-axis.
◇	61-39	292-1362	< 3	Natural sapphire; spectrographic analysis 0.5 - 5.0 Si, 0.2 - 2.0 Fe, 0.3> V, 0.2> Cu, 0.1> Mg, 0.08> Hg, 0.08> Na, 0.04> Ti, 0.03> Sn, 0.02> Ca, 0.01> Ni, 0.01> Mn, and 0.008> Cr.	-325 mesh alpha-alumina powder was coated uniformly on surface of alumina block before measurement with x-ray diffractometer; measured along a-axis.
△	61-39	292-1362	< 3	Same as above.	Same as above except measured along c-axis.
▽	58-7	297-1781		Synthetic sapphire.	



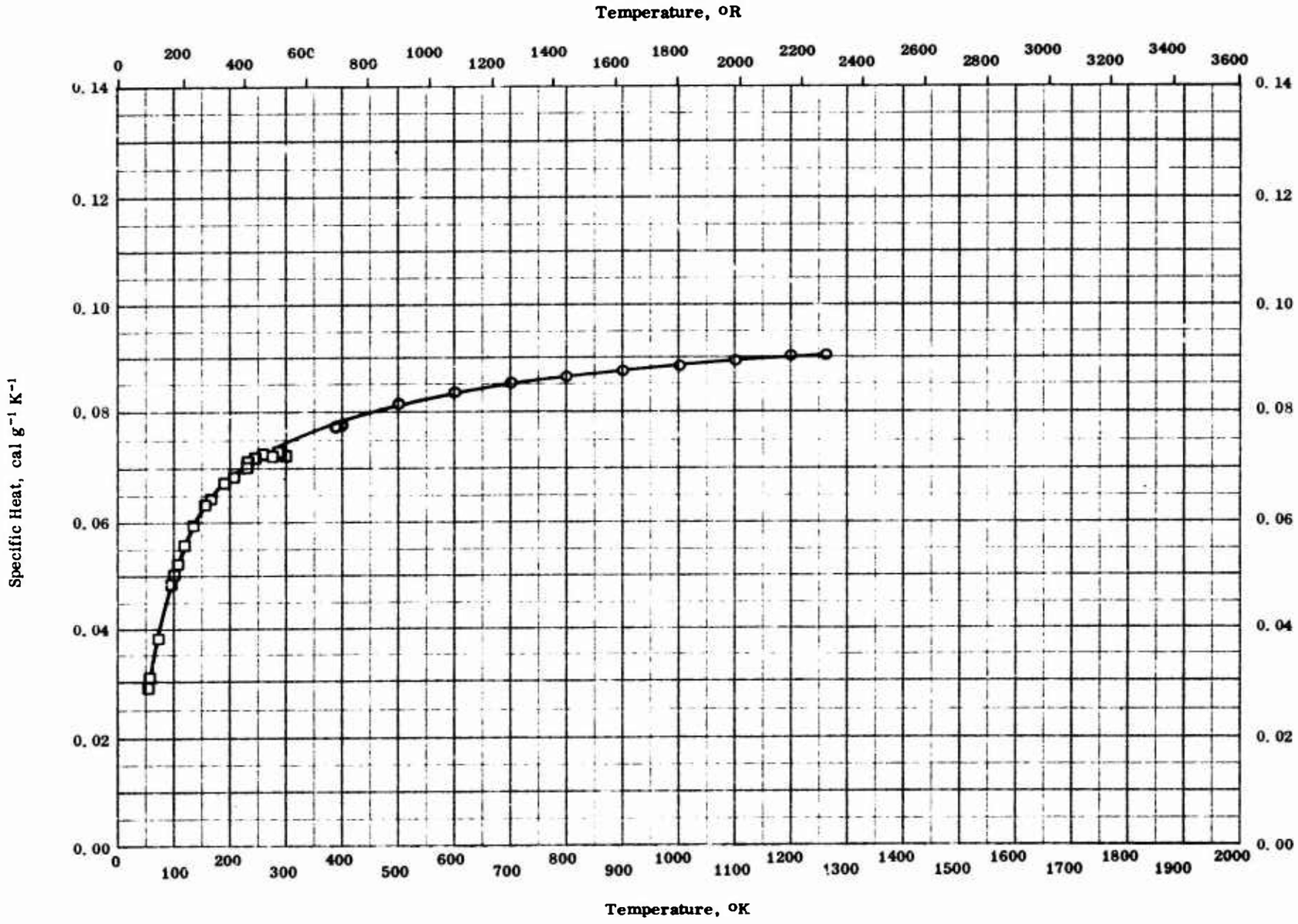
TPRC

ELECTRICAL RESISTIVITY -- BARIUM OXIDE

ELECTRICAL RESISTIVITY -- BARIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	56-13	667-1178		BaO; prepared from chemically pure polycrystalline materials.	Sintered at 0.46 MP for 2 hrs in vacuum.



SPECIFIC HEAT -- BARIUM OXIDE

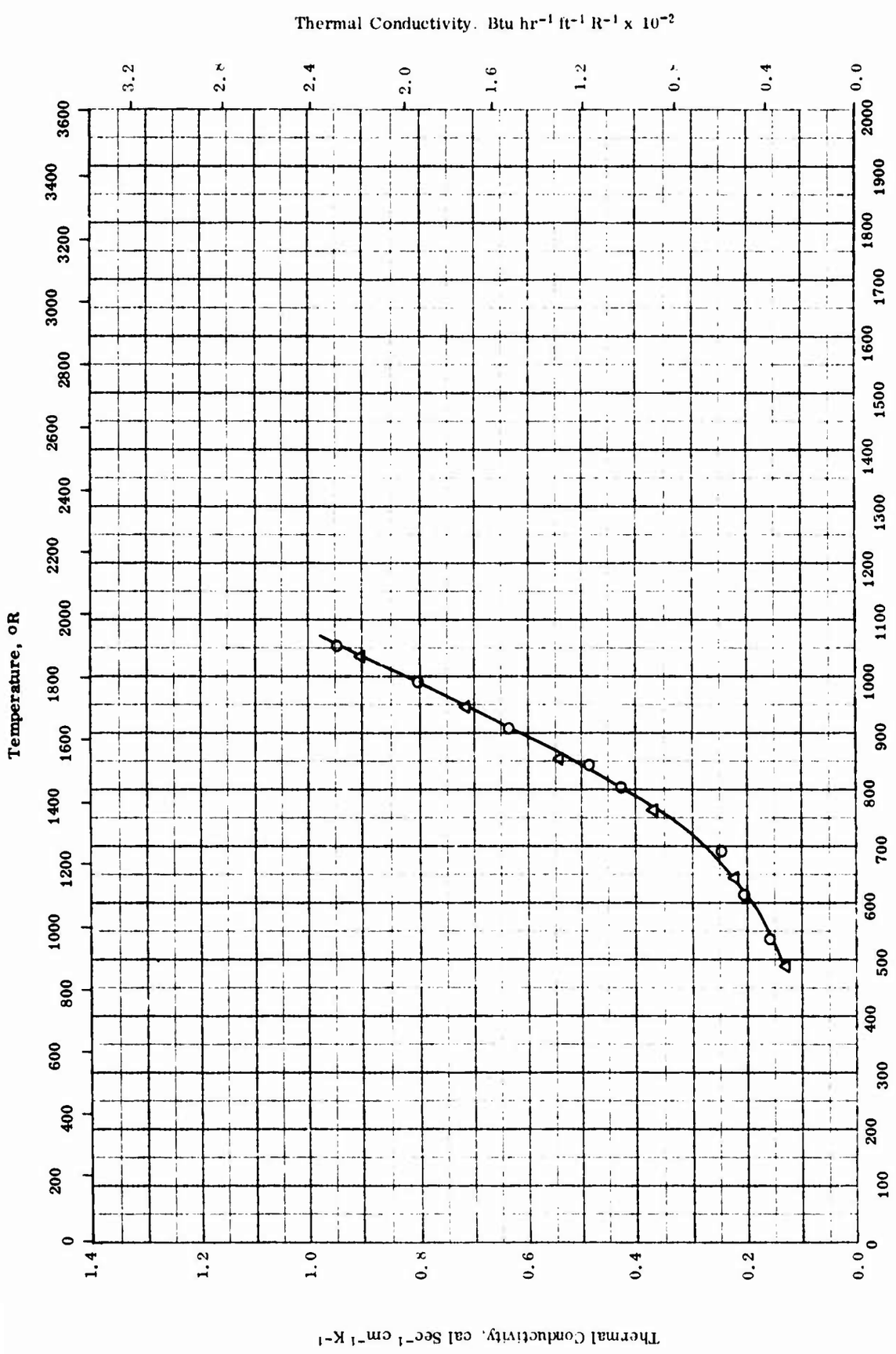
SPECIFIC HEAT -- BARIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	51-10	390-1262		99 BaO and 1.0 SiO_2.	Prepared by decomposing BaO_2.
□	35-1	56-299		Kahlbaum best grade; $CaCO_3$ as principal impurity.	Crushed to -14+35 mesh size; under high vacuum.

TPRC

Temperature, °R



THERMAL CONDUCTIVITY -- BARIUM OXIDE

THERMAL CONDUCTIVITY -- BARIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	55-8	538-1053		Polycrystal. [Author's design.: Tube No. 3].	
Δ	55-8	490-1033		Same as above. [Author's design.: Tube No. 5].	

PROPERTIES OF BERYLLIUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density	3.03	189
Melting Point	2843	5118
Heat of Fusion.	551	991.8
Heat of Vaporization . . .	4013	7223

REPORTED VALUES

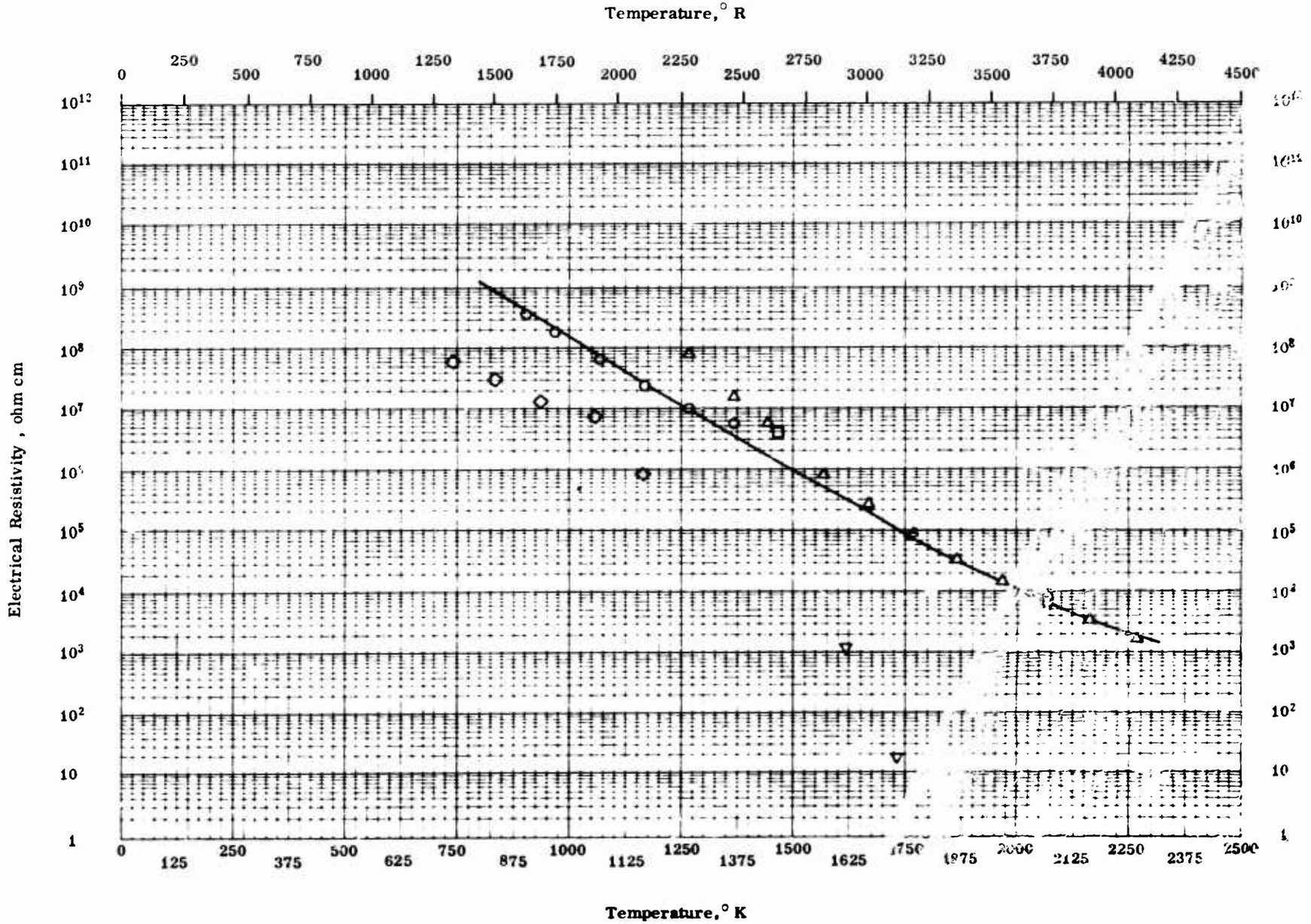
Density		$g\ cm^{-3}$	$lb\ ft^{-3}$
	○	2.96	185
	□	3.03	189
	◇	1.48	92.4
	▽	3.08	192
	▼	2.8	170
	◆	2.84 ± 0.03	177 ± 2
	▲	3.0	187.2
	■	3.02	188.7
Melting Point		K	R
	◁	2725	4905
	△	2843 ± 30	5118 ± 54
Heat of Fusion		$cal\ g^{-1}$	$Btu\ lb^{-1}$
	●	551	991 8
Heat of Vaporization		$cal\ g^{-1}$	$Btu\ lb^{-1}$
	▷	4013	7223

PROPERTIES OF BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	50-9	298		35.66 Be, 63.24 O_2, and 0.08 free C.	Hot-pressed; density by weight in air and in distilled water.
□	50-9	298		Same as above.	Same as above except computed from X-ray measurement.
▽	50-11	298		1.0 > Ca, 0.01 >each Mg, Na, and Si.	From Be hydroxide; calcined 1 hr at 1000 C, and pressed at 52000 psi; density from X-ray measurement.
◇	50-11	298		Same as above.	Same as above.
▼	50-11	298		Same as above.	From Be hydroxide; calcined 1 hr at 1000 C and fired at 1900-2100 C.
◆	57-13	298		BeO.	Density by weight in air and in kerosene.
◁	54-26	2725	± 2	BeO.	Average of 3-5 tests by visual observation.
●	61-25	—		BeO.	
▷	61-25	—		BeO.	
■	61-25	278		BeO.	
▲	60-22	298		BeO.	
△	58-15	2813-2873		BeO.	

TPRC



TPRC

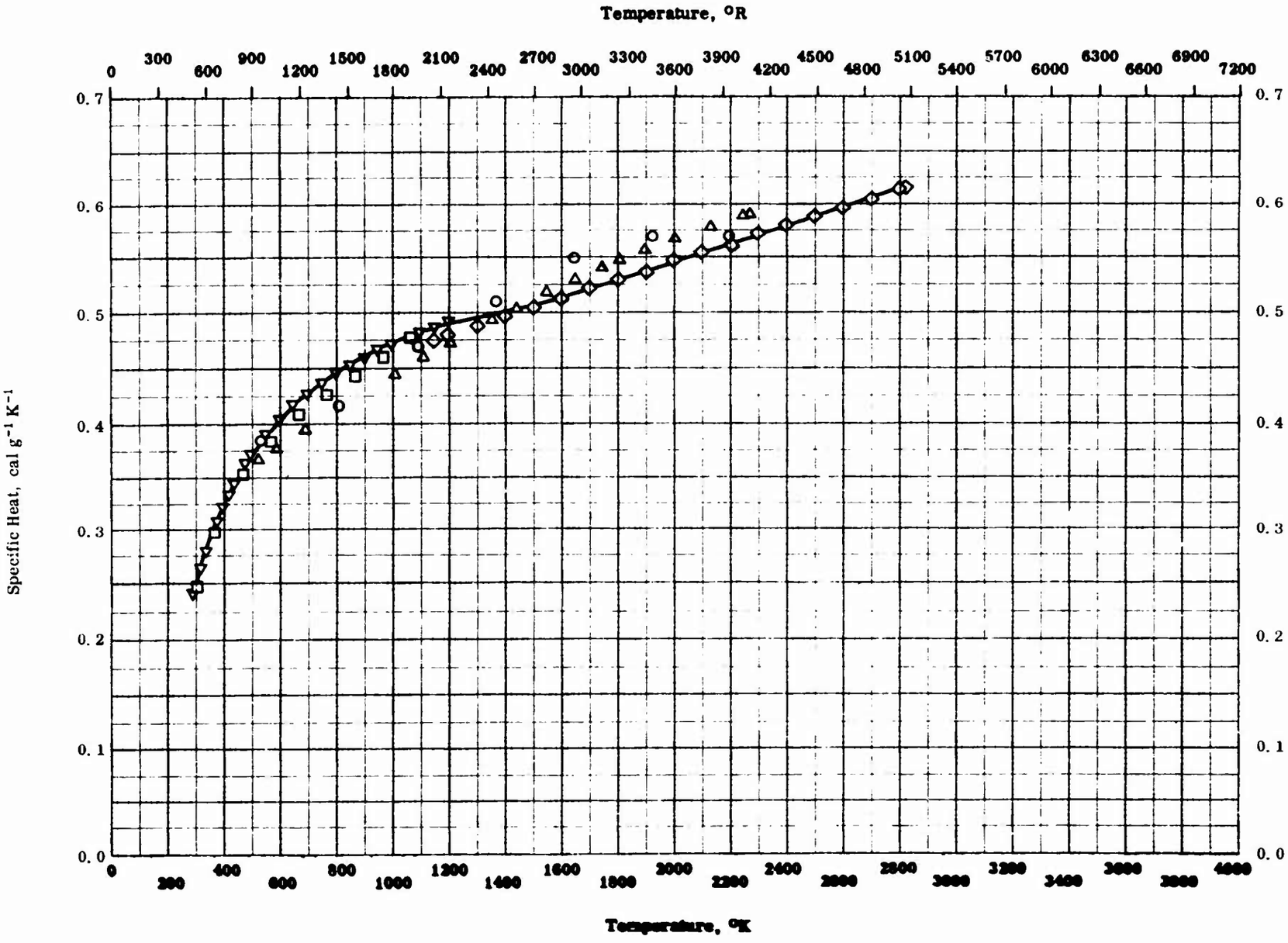
ELECTRICAL RESISTIVITY -- BERYLLIUM OXIDE

ELECTRICAL RESISTIVITY -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	40-3	903-1373		BeO; 1 cm cube samples.	Plantinized surfaces; auth. est. accuracy order of magnitude only.
□	49-3	1473-2073		BeO.	
△	42-4	973-2373		Pure BeO, Glucina; density 140 lb ft^{-3}.	Calcined at 2100 C; optical pyrometer has precision of ±7 C at 2000 C.
◇	56-13	739-1167		Polycrystal BeO; formed from chemically pure materials.	Baked and calcined 2 hrs at const. temp. in furnace; meas. under 10^{-5} mm Hg, const. current.
▽	62-4	1622-1727	2.4	BeO.	Pressed and sintered; max. exposure temperature 3965 F; sample sheared along 45° plane and became crumbly.

TPRC



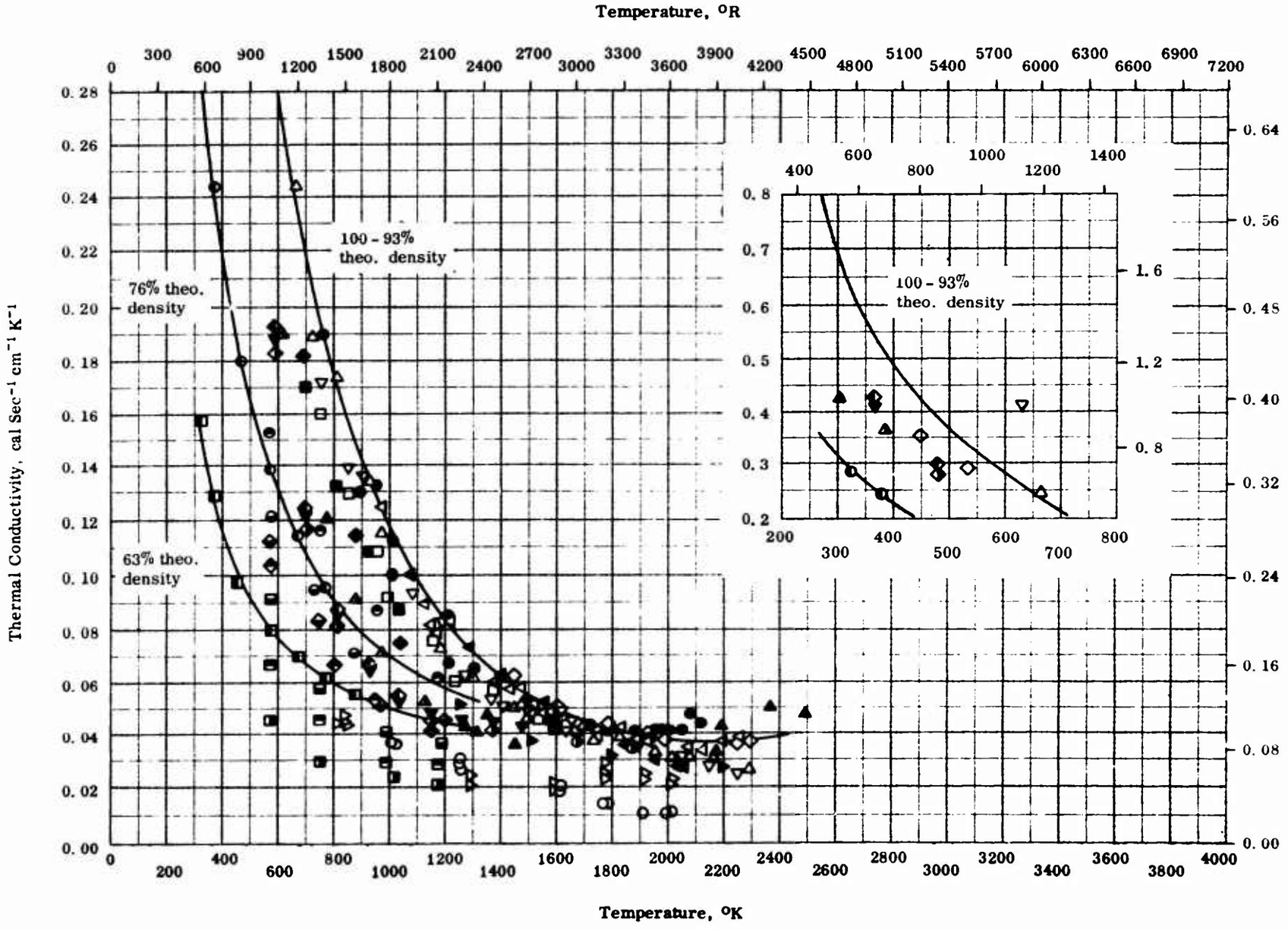
SPECIFIC HEAT -- BERYLLIUM OXIDE

SPECIFIC HEAT -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-4	533-2200	≤5.0	BeO; density 187 lb ft^{-3}.	Crushed in hardened steel mortar to pass 100-mesh screen; pressed and sintered.
□	62-13	303-1073	±3.0	Not given.	
△	63-5	527-2277	±5.0	99.5 BeO, 0.0090 Si, 0.0020 Mo, 0.0010 Ca, 0.0010 Cr, 0.0010 Fe, 0.0010 Na, 0.0010 Ni, 0.0003 Mn, 0.0001>B, Cd, and Li, and 0.0001>Co and Cu, density 179 lb ft^{-3}.	Cold pressed.
◇	60-9	1142-2820	0.25-0.5	99.9 BeO, impurities are Al, Cu, Fe, Hg, Ni, Ti and Zn.	Pressed and sintered with 0.1 glucose as cementing substance at 1400-1800 C.
▽	63-18	298-1200	0.40	99.96 BeO, 0.01 Si, 0.007 Al, 0.002 K, 0.002 Na, 0.001 Cs, 0.001 Fe, 0.001>Ca, 0.001>Cu, 0.00005>Li, and 0.00005>Mg.	Pressed; fired at 1800 C and sintered.

TPRC



THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-4	1006-2009	5-7	BeO.	Ground and polished thoroughly; sample found broken on post inspection.
▷	62-4	818-2018	5-7	BeO.	Same as above except sample found cracked on post inspection.
△	60-6	665-2290		Brush sp grade BeO with 0.27 metallic impurities; average grain size 50; density 2.89 g cm^{-3}.	Hot-pressed.
▽	60-6	630-2242		Same as above except density 2.87 g cm^{-3}.	Same as above.
□	60-6	750-1669		Pure beryles of the Nat'l. Beryllia Corp.; density 2.72 g cm^{-3}.	Slip cast.
◁	60-6	970-2256		0.0700 metallic impurities; average grain size 60; density 2.98 g cm^{-3}.	Hot-pressed at 1700 C and 4000 psi for 4 hrs.
◇	60-6	1175-2293		Same as above.	Same as above.
◆	63-5	450-1039	± 4	99.5 BeO, 0.009 Si, 0.005 Al, 0.003 Mn, 0.002 Mo, 0.001 Ca, 0.001 Cr, 0.001 Fe, 0.001 Ni, 0.001 Na, 0.001 ≥ B, Cd, and Li, and 0.001 ≥ Co and Cu; density 179 lb ft^{-3}.	Cold-pressed and fired at 2880 F; surface ground.
▶	63-5	1250-2200	± 4	Same as above.	Same as above except measured by another method.
◀	63-2	1073-2053		BD-98 from Coors Porcelain Co.; 97% of the theoretical density.	
◕	60-6	761-2131		1.0 MgO; average grain size 60; density 2.99 g cm^{-3}.	Hot-pressed at 1700 C and 4000 psi for 4 hrs.
■	61-4	700-1700		BeO.	

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TPRC

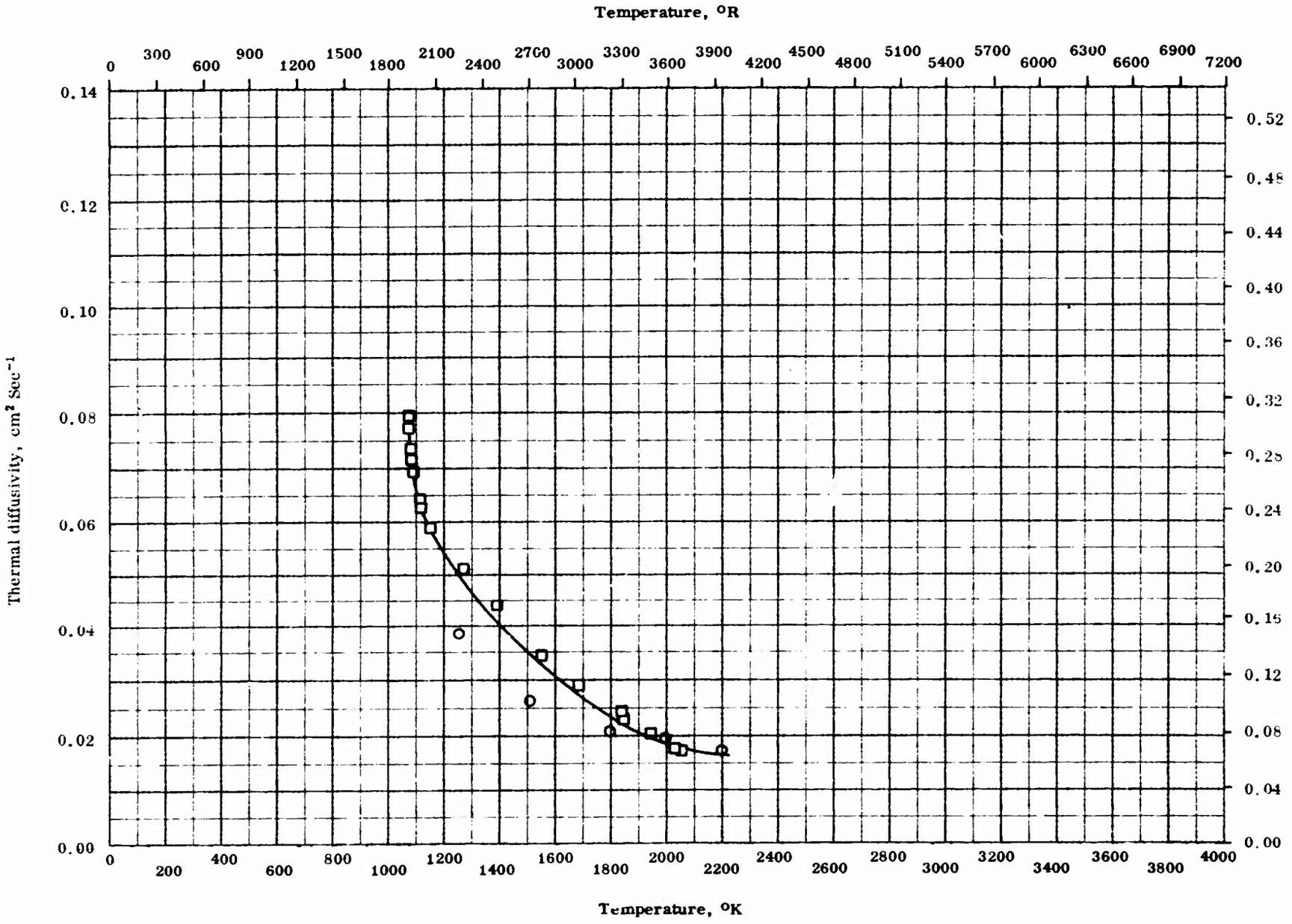
REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▲	64-1	1273-2493		UOX-grade BeO; 97.8% theoretical density.	Made from UOX-grade BeO powder; crushed and screened through a 20-mesh sieve after isostatically pressed at 7000 psi, cold-pressed at about 6500 psi, and again isostatically pressed at 20,000 psi; sintered in dry hydrogen at 1700 C for approx 6 hrs and then machined; data corrected to 100% theoretical density.
▼	61-5	367-1478		UOX-grade by Brush; 96 - 97% of theoretical density.	Dry-pressed followed by isostatically pressing, sintered at 2950 F in H_2 for 2 hrs, and then heat treated at 3200 F in H_2 for 1 hr.
◆	61-5	367-1478		Same as above.	Same as above.
◆	61-5	367-1367		Same as above.	Same as above; data corrected to zero porosity.
◑	54-10	1273-2073		99.7 BeO, 0.18 MgO, 0.08 Al_2O_3, 0.01 Fe_2O_3.	Prepared by slip casting refractory grade (220 mesh) BeO.
◐	54-11	323-873		> 99 BeO, main impurity Al_2O_3; density 143 lb ft^{-3}.	Fired at 1750 C.
◧	54-11	323-873		> 99 BeO, main impurity Al_2O_3; density 115 lb ft^{-3}.	Fired at 1750 C.
◨	57-6	573-1173		Density 118 lb ft^{-3}.	Prepared from 200 mesh refractory grade powder by dust pressing.
◒	57-6	573-1173		Density 129 lb ft^{-3}.	Same as the above specimen.
◓	57-6	573-1173		Density 125 lb ft^{-3}.	Prepared from 200 mesh refractory grade powder by extrusion of blanks fired at 2800 F and 3100 F.
				(Continued onto next page)	

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE (continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◆	57-6	573-1173		Density 136 lb ft^{-3}.	Same as the above specimen.
◆	57-6	573-1173		Density 132 lb ft^{-3}.	Prepared from 200 mesh refractory grade powder by hot pressing.
⊖	57-6	573-873		Density 140 lb ft^{-3}.	Same as the above specimen.
⊖	57-6	573-1173		Density 179 lb ft^{-3}.	Same as the above specimen.
▲	51-4	322-1500	± 8	99.6+ BeO; density 165 lb ft^{-3}; 10% total porosity.	Slip cast.



THERMAL DIFFUSIVITY -- BERYLLIUM OXIDE

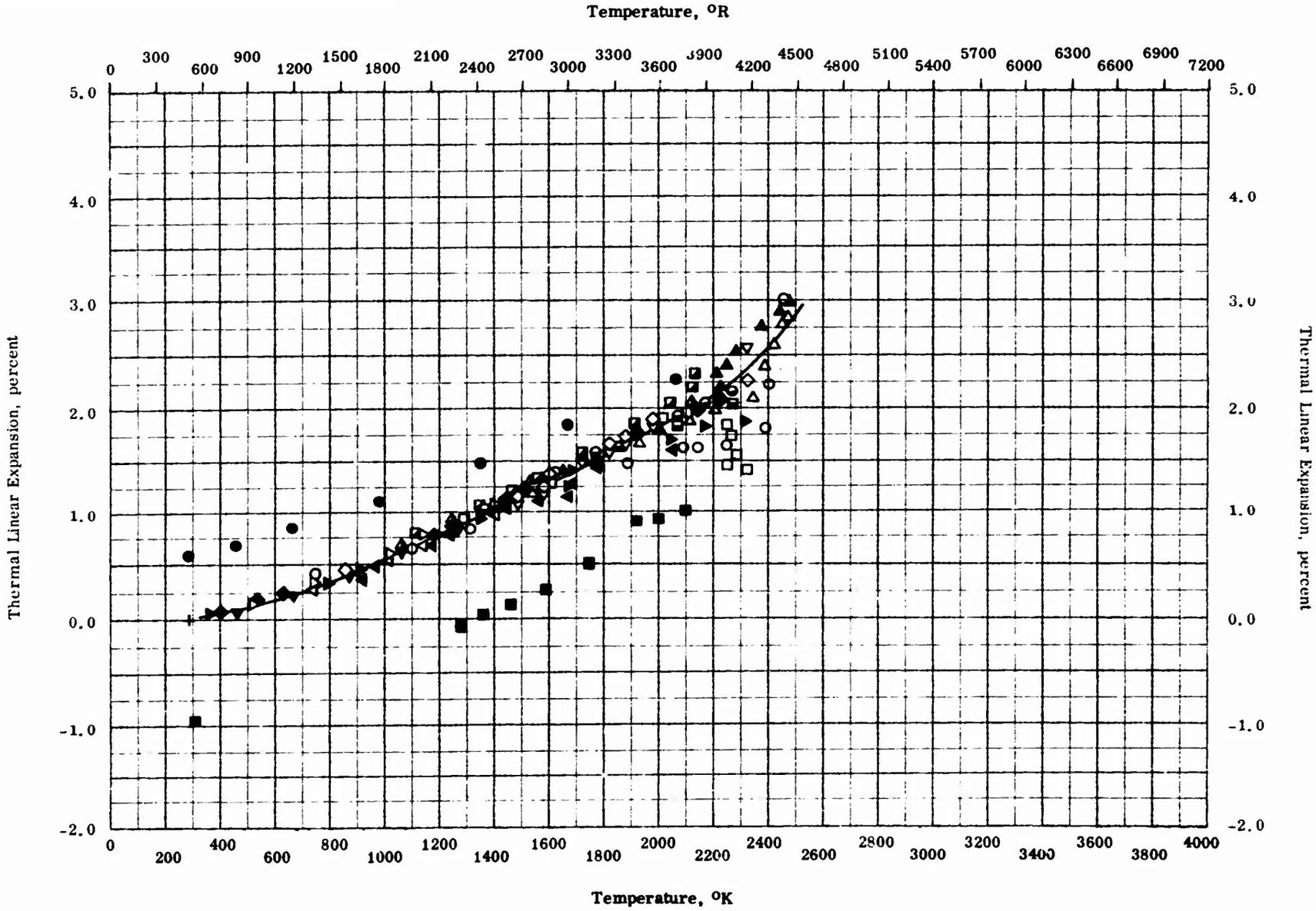
THERMAL DIFFUSIVITY -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	63-5	1250-2200		99.5 BeO, 0.0090 Si, 0.0050 Al, 0.0020 Mo, 0.0010 Fe, Ni, Ca, Cr, and Na each, 0.0003 Mn, 0.0001> B, Cd, Li, and 0.0001> Co, Cu; density 179 lb ft^{-3}.	Cold pressed and fired at 2880 F.
□	63-2	1070-2046	± 5- ± 10	BD-98 from Coors Porcelain Co., density 2.93 g cm^{-3}.	

TPRC

Temperature, °R



THERMAL LINEAR EXPANSION -- BERYLLIUM OXIDE

THERMAL LINEAR EXPANSION -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error	Sample Specifications	Remarks
◇	60-37	298-2323		BeO.	All x-ray camera exposures made with CuK_{α} radiation for approx. 2 hrs; measured parallel to a-axis.
▽	60-37	298-2323		BeO.	Same as above except measured parallel to c-axis.
▷	62-28	301-1405	2-3	99+ BeO; hexagonal.	Mixture of 70 BeO and 30 Pt powder was fired at 1500 C for 12 hrs, cooled to room temperature, spread uniformly on a flat alumina holder, and re-fired at 1000 C for 3 hrs; Pt powder used for furnace alinement and thermal calibration; measured along a-axis with x-ray diffractometer.
◁	62-28	301-1405	2-3	Same as above.	Same as above except measured along c-axis.
○	62-4	294-2458	5	BeO, Zirconium Corp. of America; density at 25 C by ASTM method B311-58 2.93 g cm^{-3}; initial length 3.031 in. [Author's design: Run No. E 21].	Pressed and sintered; measured in helium atm.
●	62-4	294-2458	5	Same as above; final length 3.051 in.	Cooling cycle for above sample.
◆	63-5	299-2233	2	BeO, Brush Beryllium Co.; 99.5 BeO, 0.005 Al, 0.009 Si, 0.002 Mo, 0.001 Fe, Ni, Cr, Ca, Na, 0.0003 Mn, and trace of B, Cd, Li, Co, Cu; densith 179 lb ft^{-3}; dimensions 1/2 in. diameter by 6 in. long.	Cold pressed and fired at 2880 F; measured in argon atm with heating rate of approx. 5 F min^{-1}.

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TPRC

REFERENCE INFORMATION

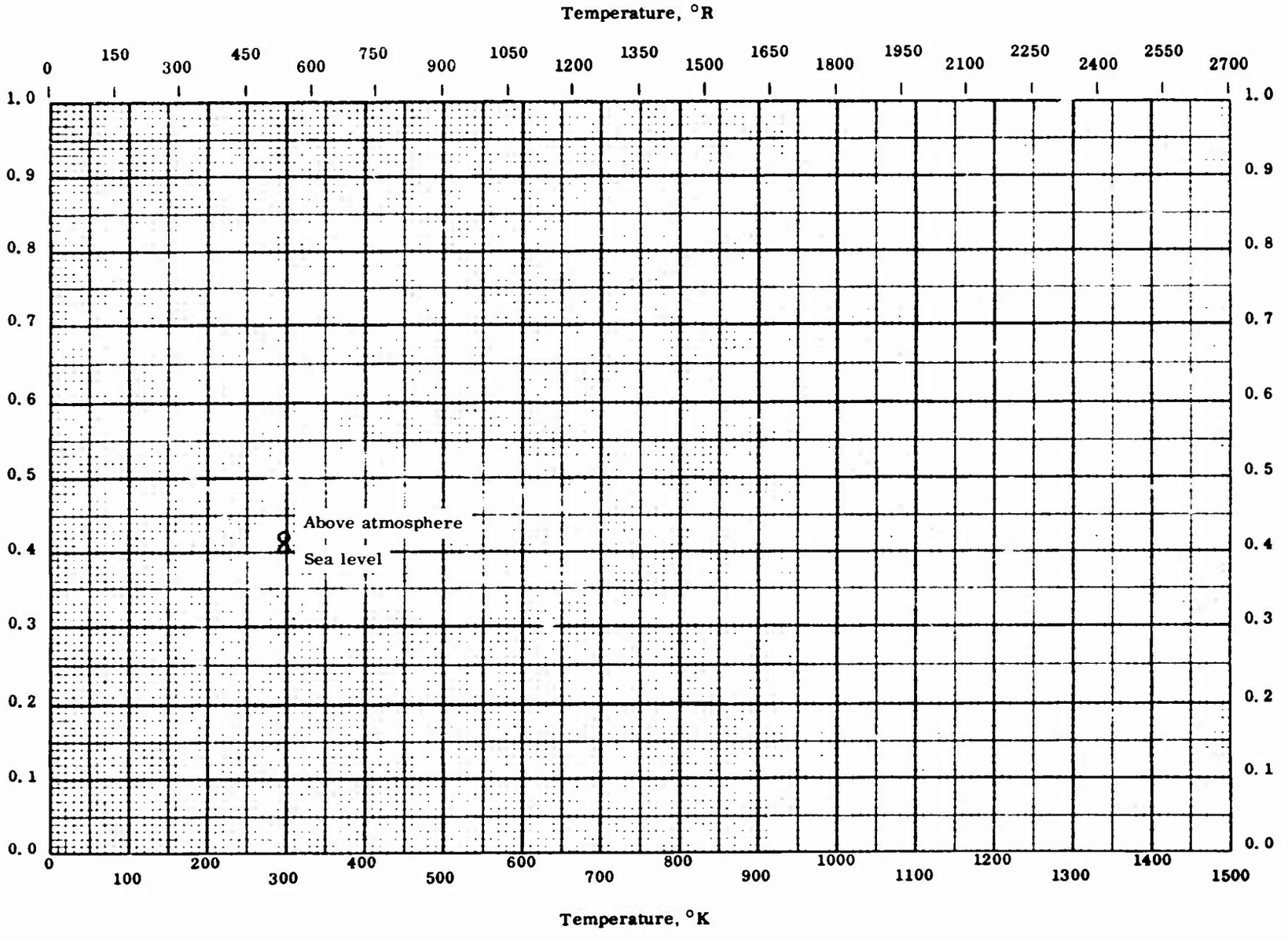
Symbol	Ref.	Temp. Range °K	Rept. Error	Sample Specifications	Remarks
▼	63-34	293-1273		Prepared from Beryllium Corporation's High Purity Grade 1 BeO powder; translucent oxide; 99.5% theoretical density; dimensions 2 in. diameter by 1/4 in. thick.	Blended, wet screened, temperature to 1750 C, held for 10 min, pressure slowly applied in increments of 300 psi until 4000 psi was reached, held at hot pressing temperature for 4 hrs, and cooled overnight; measured in air atm.
▶	58-21	293-2313		BeO from Commissariat a'l' Energie Atomique, Saclay, France; polycrystal; fine grain.	Hot pressed in graphite molds; measured along a-axis.
◀	58-21	293-2058		Same as above.	Same as above except measured along c-axis.
⊖	63-36	293-2273		Prepared from precalcined (1800 C) chemically pure beryllia (99.9 BeO); dimensions 4 by 4 by 20 mm; bulk density 2.84 g cm^{-3}; zero apparent porosity. [Author's design: Body 15]	Pressed at 1000 kg cm^{-2} and fired at 1950 C; measured in vacuum furnace; authors reported average coefficients.
□	58-20	308-2329		S.P. grade BeO from Oak Ridge; density 2.74 g cm^{-3}. [Author's design: Sample EP 1-2]	Hot pressed; measured in argon atm; sample sintered at 2000 C during run.
■	58-20	313-2101		Same as above.	Cooling cycle for above sample.
◪	58-20	298-2138		Same as above.	Second heating cycle for above sample.
△	58-20	300-2473		S.P. grade BeO; density 2.94 g cm^{-3}. [Author's design: Sample No. DQ-1]	Hot pressed; measured in argon atm.
▲	58-20	1178-2473		Same as above.	Cooling cycle for above sample.
▲	58-20	293-2258		BeO density 2.76 g cm^{-3}. [Author's design: Sample No. FF-1]	Slip cast and sintered in oxidizing atm at 1800 C; measured in argon atm.

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THERMAL LINEAR EXPANSION -- BERYLLIUM OXIDE (Continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◘	58-20	293-2273		S.P. grade BeO from Oak Ridge; density 2.74 g cm^{-3}. [Author's design: EP 1-3]	Hot pressed; measured in argon atm.



SOLAR ABSORPTANCE -- BERYLLIUM OXIDE

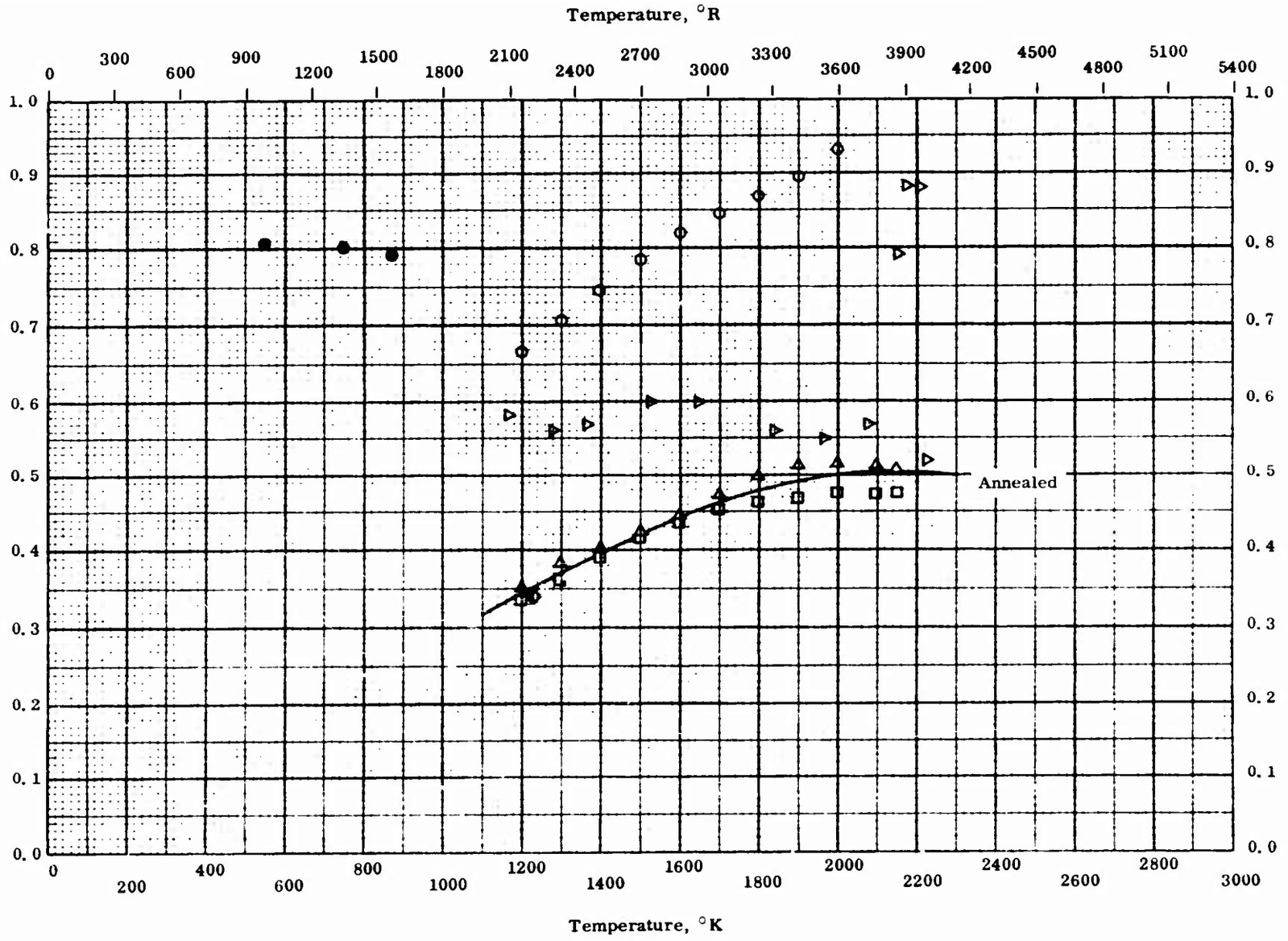
SOLAR ABSORPTANCE -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	57-27	298		BeO.	As received; above atmosphere.
△	57-27	298		BeO.	Same as above; sea level.

TPRC

Temperature, °R

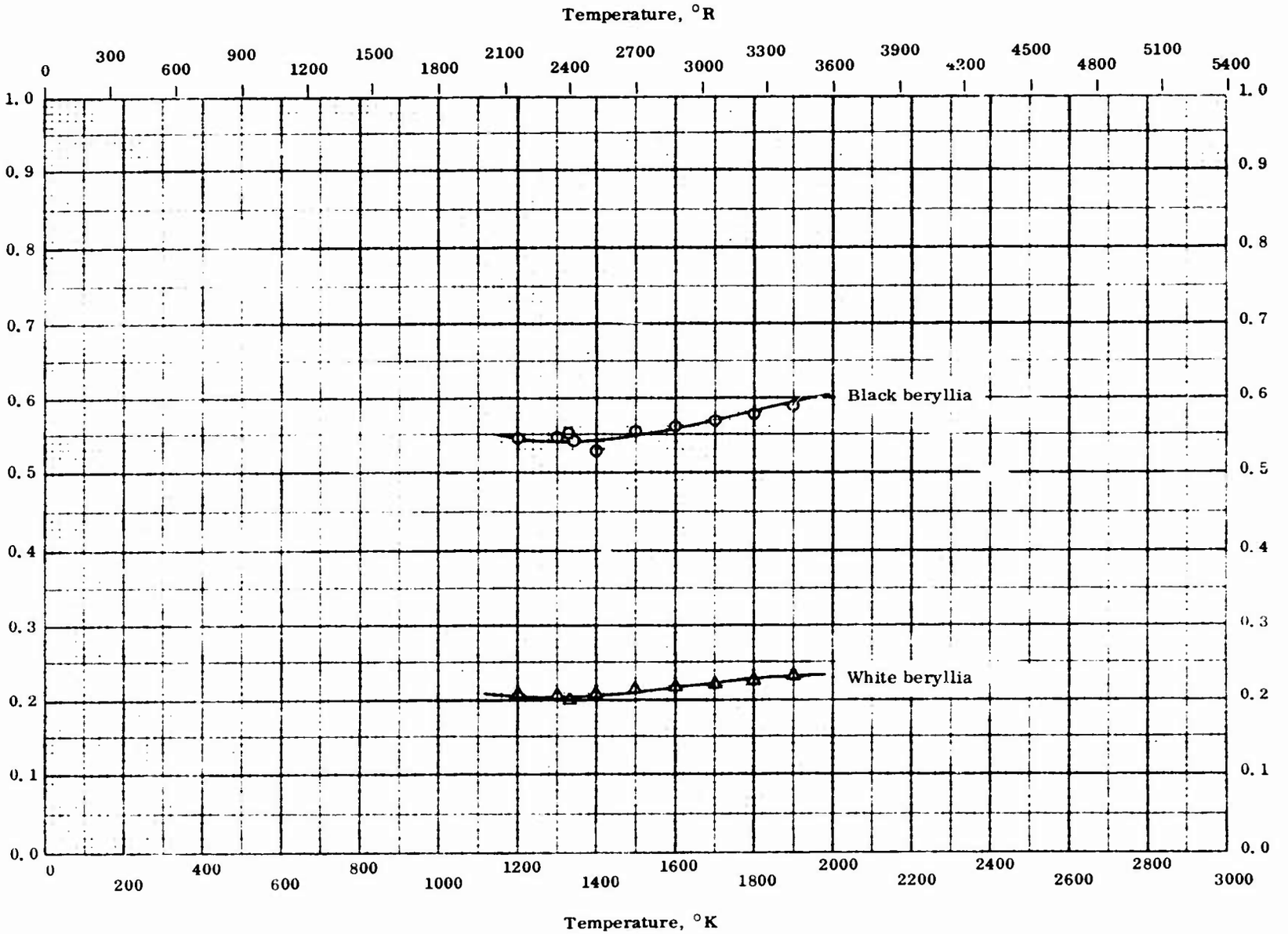


NORMAL TOTAL EMITTANCE -- BERYLLIUM OXIDE

NORMAL TOTAL EMITTANCE -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error σ_c	Sample Specifications	Remarks
○	48-2	1200-2000	20	BeO; density 2.85 g cm^{-3}.	Hot pressing high fired beryllia powder in graphite forms; surfaces ground parallel and polished on No. 500 carborundum paper; initial heat in air to 1573 K then heat treated in vacuum to outgas the sample and volatize impurities.
△	48-2	1200-2150	20	BeO, Brush S. P. powdered beryllia; density 2.844 g cm^{-3}.	Hot-pressed; same as above; small holes appeared at the center of many dark regions.
□	48-2	1200-2150	20	Same as above; density 2.778 g cm^{-3}.	Hot-pressed and annealed.
●	59-15	555-866		BeO.	Measured in air.
▷	62-4	1170-2209	10	BeO; density 3.0 g cm^{-3}.	Pressed and sintered; measured in dry argon atmosphere.
◆	63-26	1223	± 8	BeO, plate, 0.065 in. thickness, density 1.84 g cm^{-3}.	Sintered at 1973 K for 2 hrs; measured in argon atmosphere; computed from spectral data.



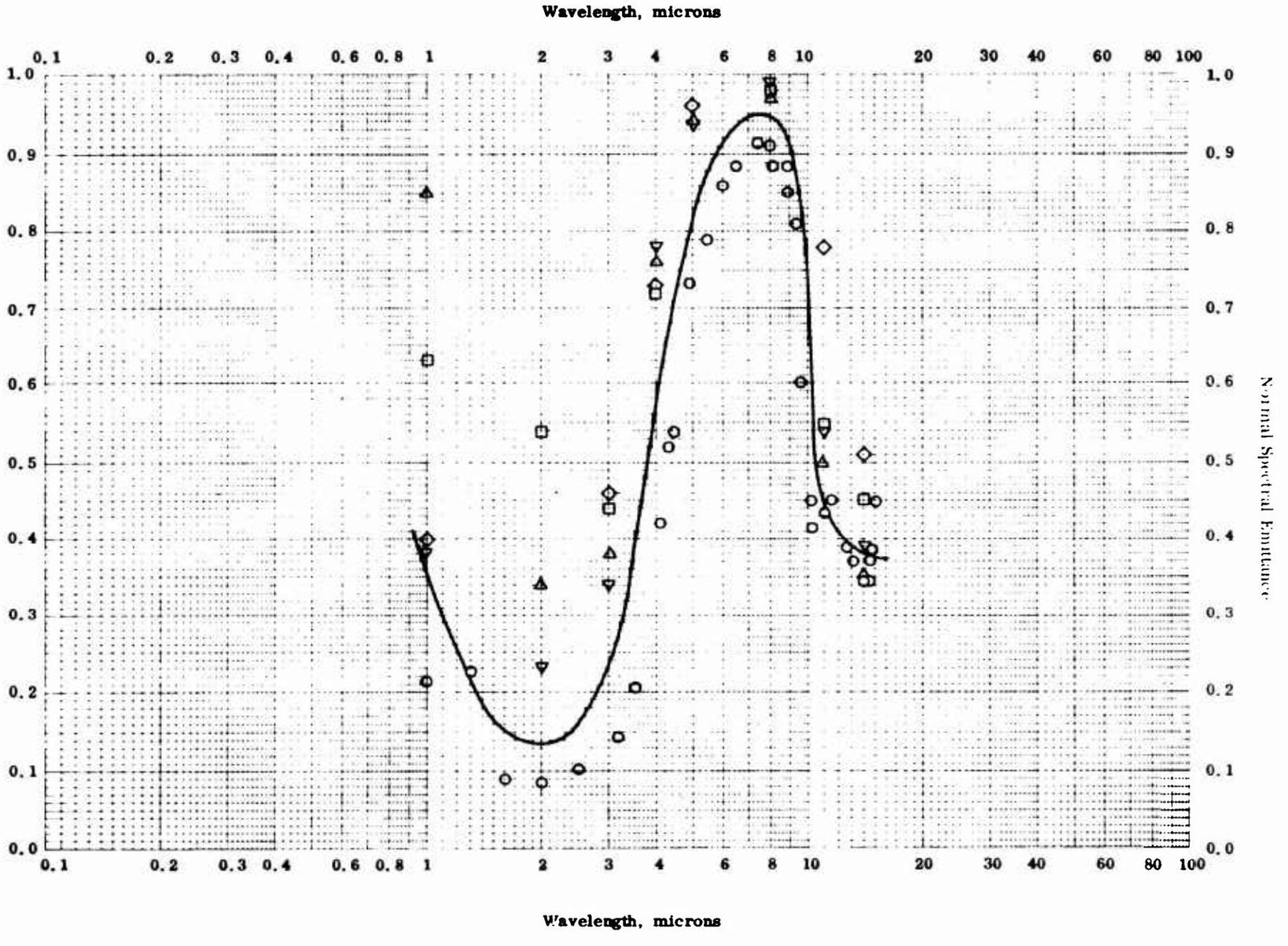
NORMAL SPECTRAL EMITTANCE -- BERYLLIUM OXIDE

NORMAL SPECTRAL EMITTANCE -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Wavelength μ	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	48-2	0.665	1200-1900	10	BeO, black beryllia; density 2.85 g cm^{-3}.	Hot-pressed in graphite form, and heated to 1873 K for 30 min.; surfaces ground parallel and polished, platinum vaporized onto beryllia surface; measured in air.
△	48-2	0.665	1200-1900	10	Same as above except white beryllia, density 2.844 g cm^{-3}.	Same as above except not pressed in graphite forms; two small (0.1 cm diameter) spots on surface.

TPRC



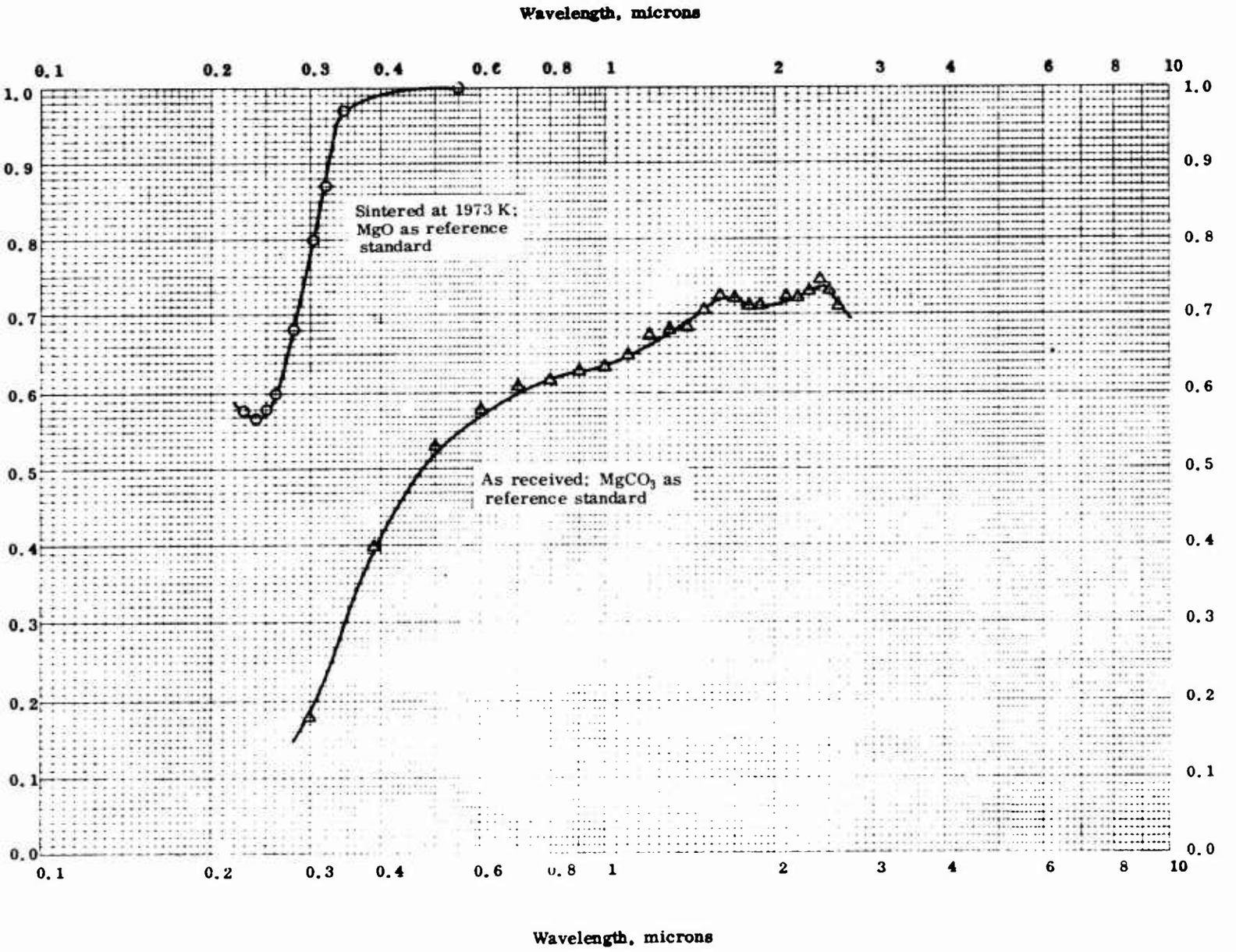
NORMAL SPECTRAL EMITTANCE -- BERYLLIUM OXIDE

NORMAL SPECTRAL EMITTANCE -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
○	63-26	1223	1-15		BeO, plate, 0.065 in. thickness, density 1.84 g cm^{-3}.	Sintered at 1973 K for 2 hrs; measured in argon atmosphere; data taken from a curve.
△	64-12	812	1-14	±5	BeO, Coors BD-98; 98 pure.	
▽	64-12	1194	1-14	5	Same as above.	
□	64-12	817	1-14	±5	96 BeO and 1 $CoCO_3$.	
◇	64-12	1587	1-14	±5	Same as above.	

TPRC



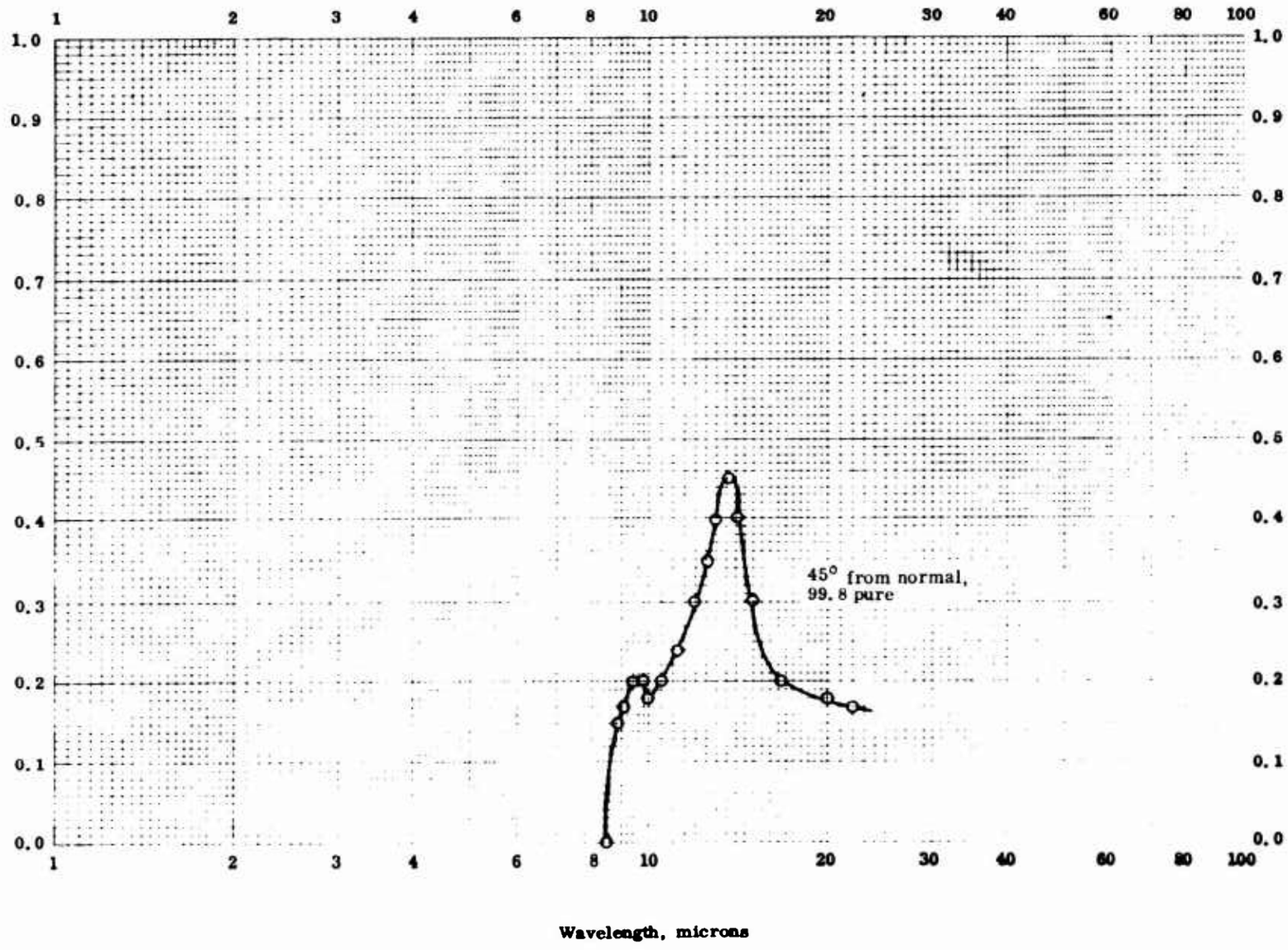
NORMAL SPECTRAL REFLECTANCE -- BERYLLIUM OXIDE

NORMAL SPECTRAL REFLECTANCE -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	63-26	298	0.23-0.55	5	BeO, pure, density 1.84 g cm^{-3}.	Sintered at 1973 K for 2 hrs; data taken from a curve; MgO as reference standard, normal illumination, hemispherical viewing.
△	57-27	298	0.3-2.6	±4	BeO.	As received; data taken from smooth curve; 6 - 9 degrees illumination, hemispherical viewing; $MgCO_3$ as reference standard.

TPRC



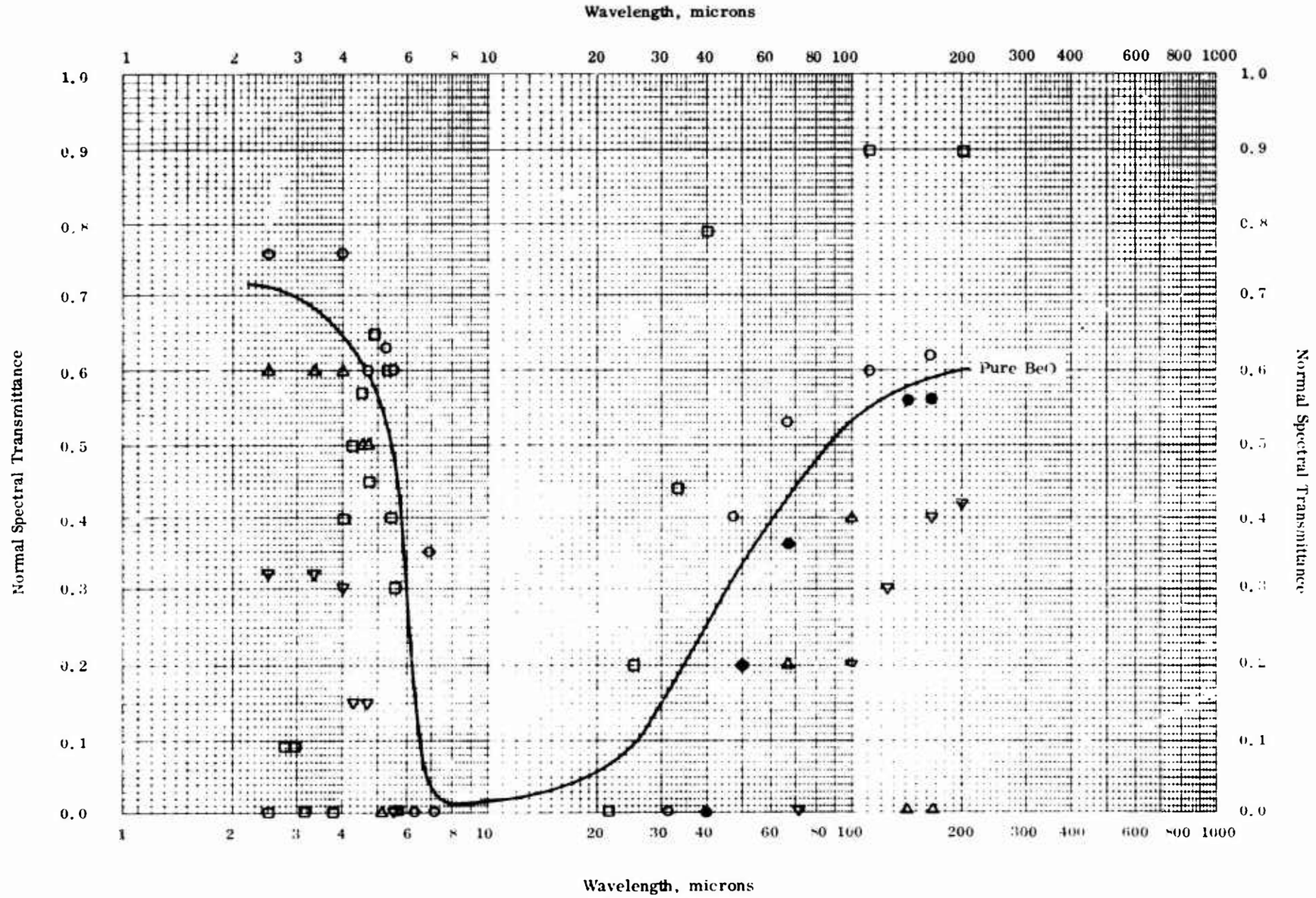
ANGULAR SPECTRAL REFLECTANCE -- BERYLLIUM OXIDE

ANGULAR SPECTRAL REFLECTANCE -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	62-24	298	8.6-22.2		BeO, 99.8 pure with Al_2O_3 and SiO_2 principle impurities; density 99.5% that of the single crystal.	Pressed; 45 degrees from normal, aluminum mirror as reference standard.

TPRC



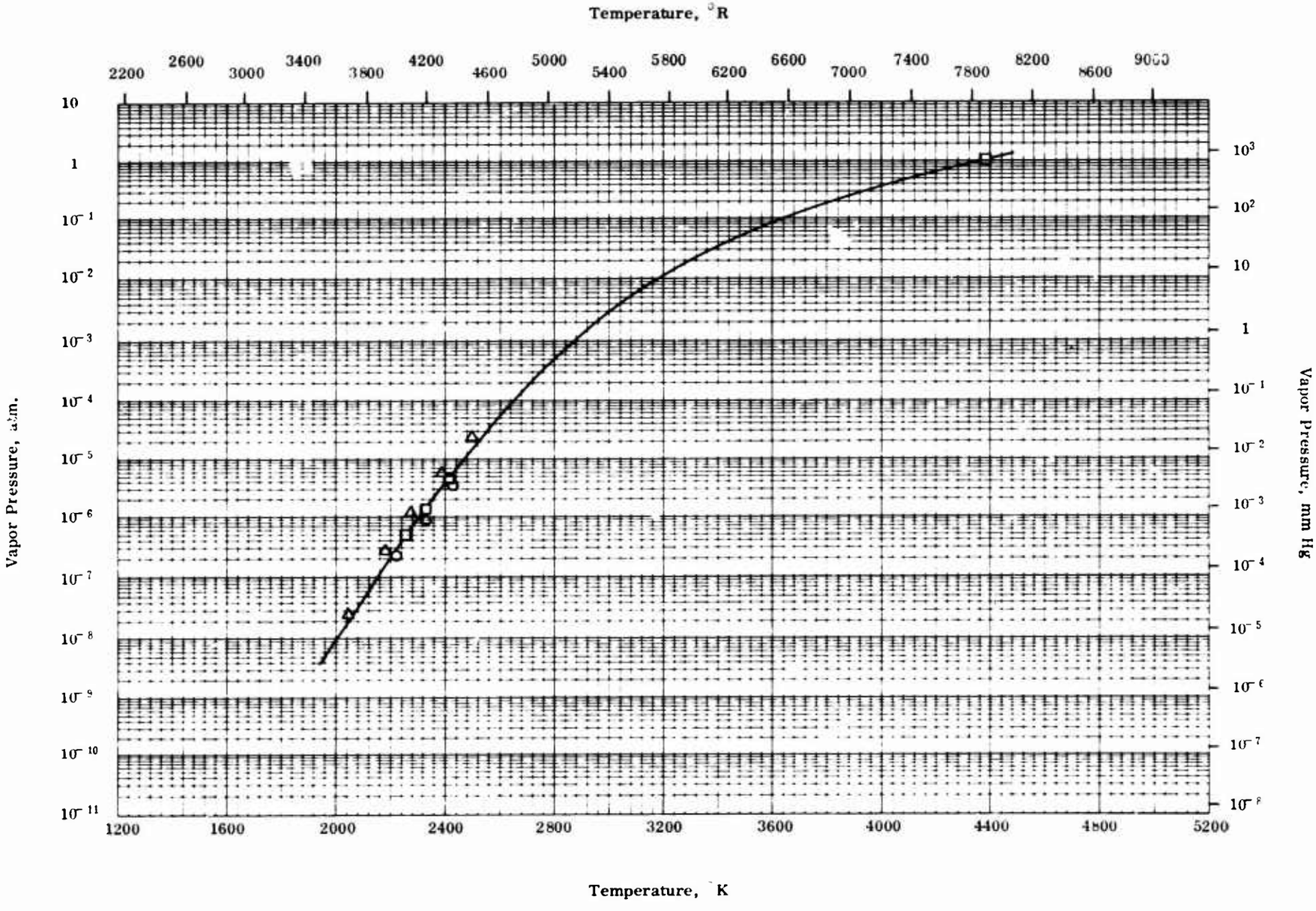
NORMAL SPECTRAL TRANSMITTANCE -- BERYLLIUM OXIDE

NORMAL SPECTRAL TRANSMITTANCE -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	62-24	2.5-166.7	±5	Pure BeO single crystal; 0.1 mm thickness.	Grown from magnesium fluoride solution.
●	62-24	40.0-166.7	±5	BeO, single crystal.	Grown from lithium molybdate.
△	62-24	2.5-166.7	±5	BeO with 1 MgO and 1 other impurities, plate of 0.3 mm thickness; density 99.5% that of the single crystal.	Pressed.
▽	62-24	2.5-200	±5	Same as above, 1.0 mm thickness.	Pressed.
□	62-24	2.5-200	±5	BeO.	Suspended in a polyethylene sheet 0.03 in. thickness, 5 mg of finely powdered BeO dispersed per sq. cm of polyethylene.

TRC

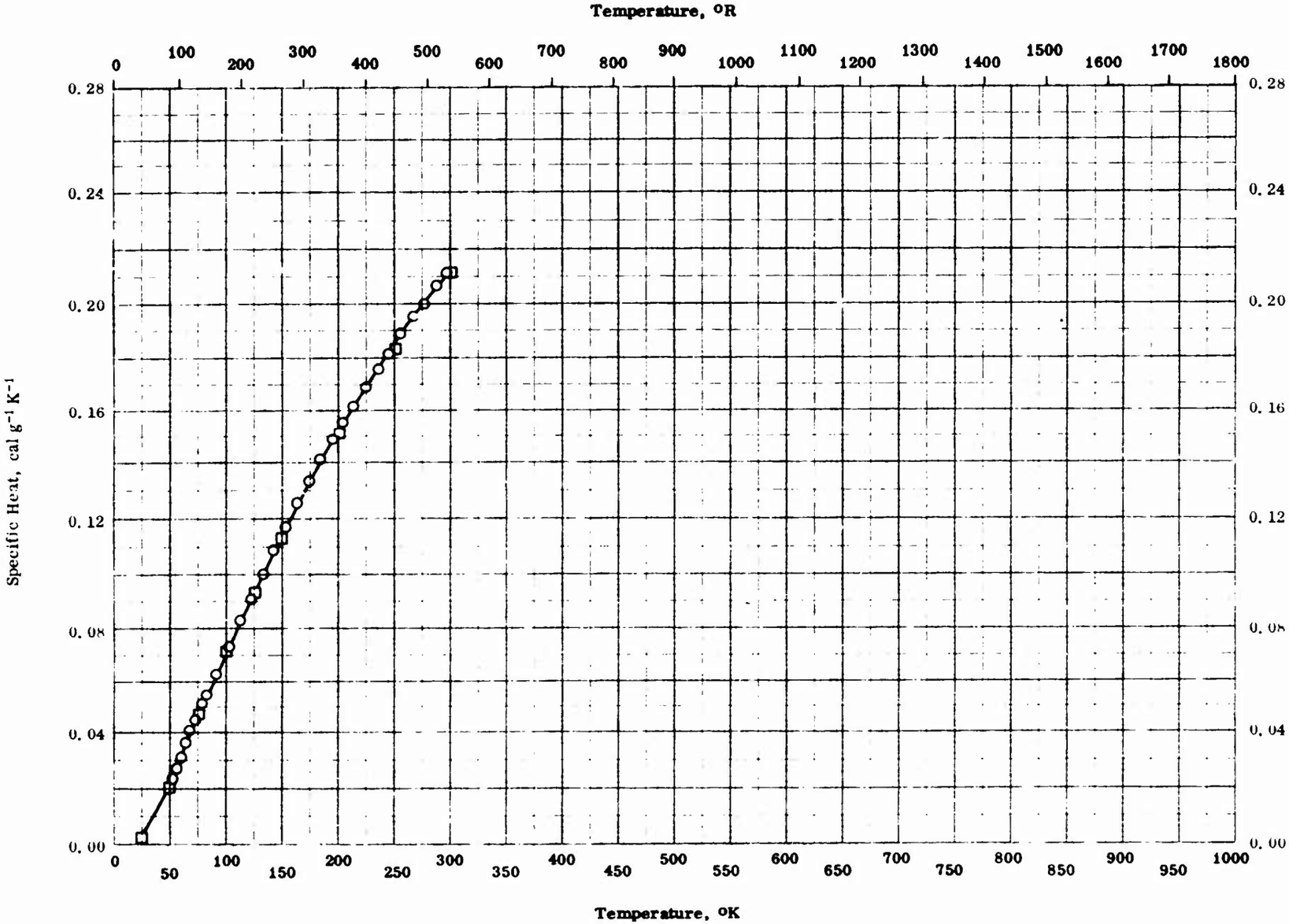


VAPOR PRESSURE -- BERYLLIUM OXIDE

VAPOR PRESSURE -- BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	47-1	2223-2423		BeO.	Calc. from author eq.: $\log_{10} p(\text{mm Hg}) = 18.32 - \frac{34,230}{T(^\circ K)} - 2\log_{10} T(^\circ K)$.
□	51-6	2250-2323		BeO, 99.2 pure crystals.	Calc. from author eq.: $\log_{10} P(\text{mm Hg}) = 18.50 \pm 0.23 - \frac{34,230 \pm 530}{T(^\circ K)} - 2\log_{10} T(^\circ K)$ from 1977 - 2140 C.
△	57-9	2041-2500		BeO.	Vapor pressure for reaction $2\,BeO \rightarrow 2\,Be + O_2$.



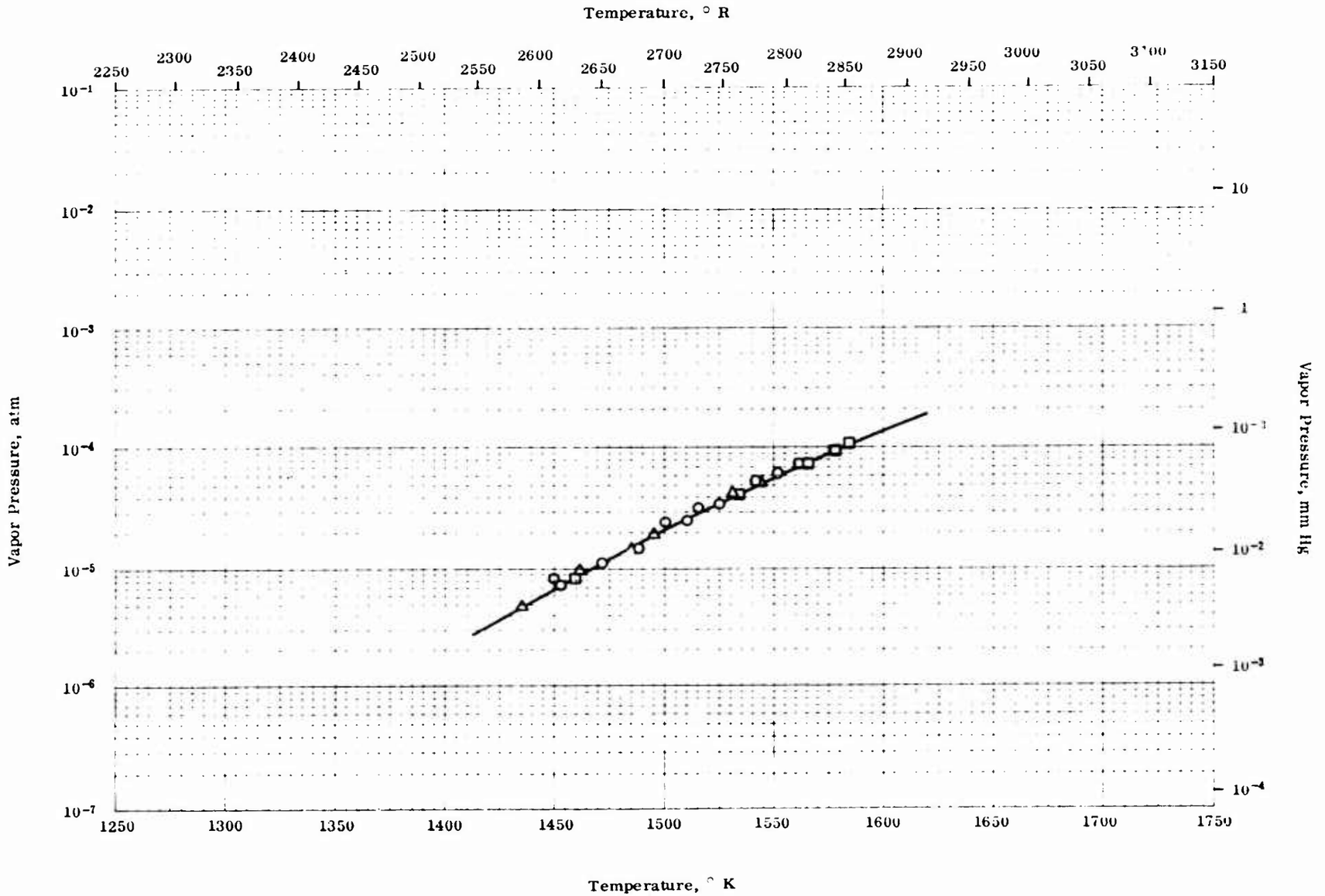
SPECIFIC HEAT -- BORON OXIDE

SPECIFIC HEAT -- BORON OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error	Sample Specifications	Remarks
○	41-6	52-298		99.7 B_2O_3, 0.10 H_2O and 0.10 unaccounted.	Prepared from boric acid by heating 1 week at 120 C after which temperature raised 10 C daily until 200 C for one day; resulting crystals heated 2 days at 400 C.
□	50-13	17-300		B_2O_3; 0.10 H_2O.	Prepared by heating boric acid (0.05 impurity) 1 week at 120 - 130 C; after which temperature increased 10 C per day until it remained at 200 C for one day; resulting mixture crystallized at 200 C over 3 days period; temperature raised to 400 C for 2 days under vacuum; resulting material crushed, screened and heated 3 more days at 400 C under vacuum.

TPRC



VAPOR PRESSURE -- BORON OXIDE

VAPOR PRESSURE -- BORON OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error	Sample Specifications	Remarks
○	63-11	1459-1562		Chemical pure grade B_2O_3.	Vacuum dried at 1100 C for several hours.
□	63-11	1459-1584		Same as above.	Same as above.
△	63-11	1436-1543		Same as above.	Same as above.

TPRC

PROPERTIES OF CADMIUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density	6.95*	434*
Melting Point	1773	3191
Heat of Sublimation . . .	$^{478}_{1028\,K}$	$^{816}_{1850R}$

*Handbook of Chemistry and Physics (Ref. 64-16)

REPORTED VALUES

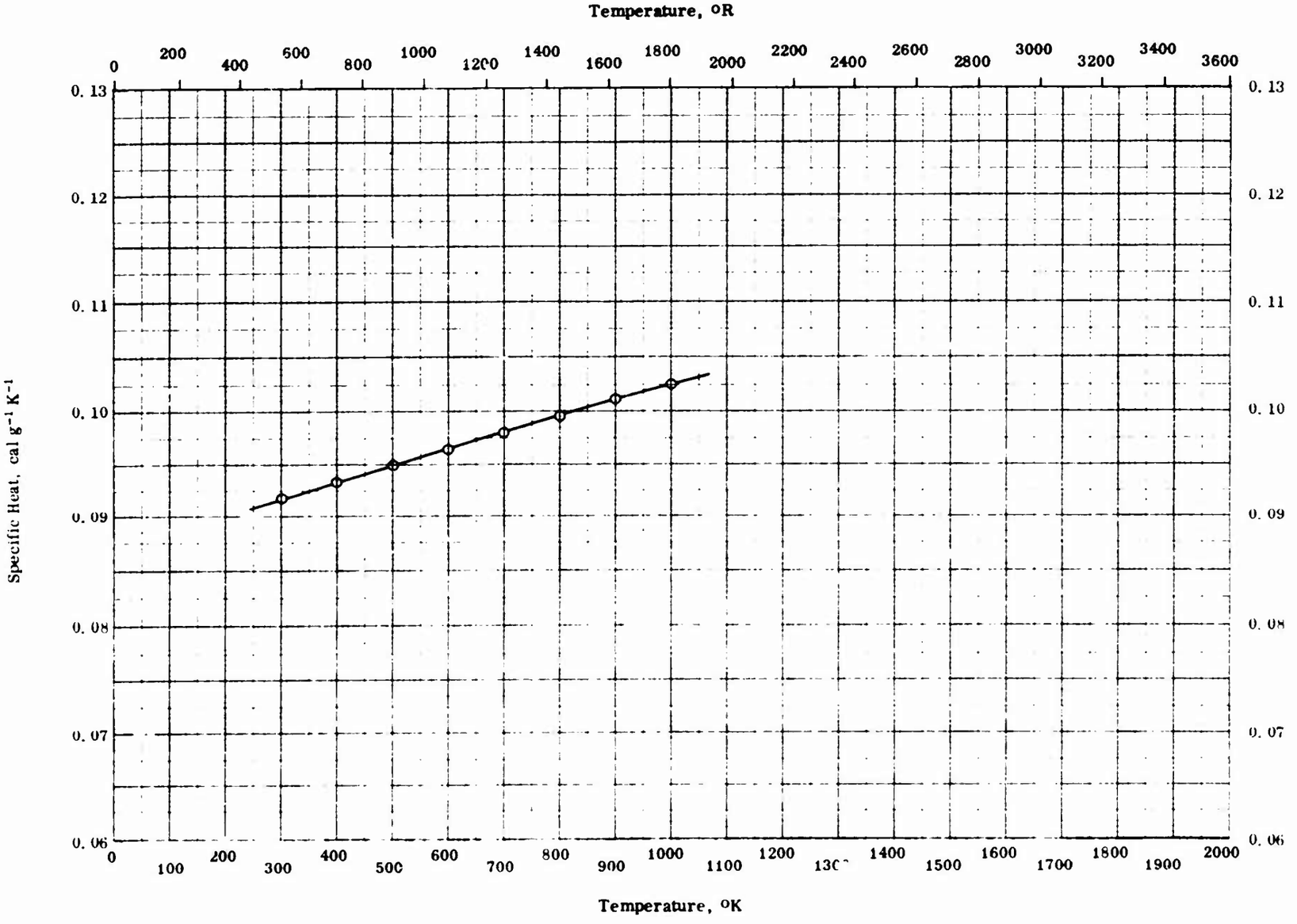
Melting Point		K	R
	□	>1773	>3191
Heat of Sublimation		cal g^{-1}	Btu lb^{-1}
	○	$^{478}_{1028K}$	$^{816}_{1850R}$

PROPERTIES OF CADMIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	41-1	1028		CdO.	Δh_S from vapor pressure data.
□	61-27	>1773		CdO; 0.001-0.01 Si, 0.0001 > Ag, and 0.0001-0.001 Al, B, Ca, Cu, Fe, Mg, and Pb.	

TPRC



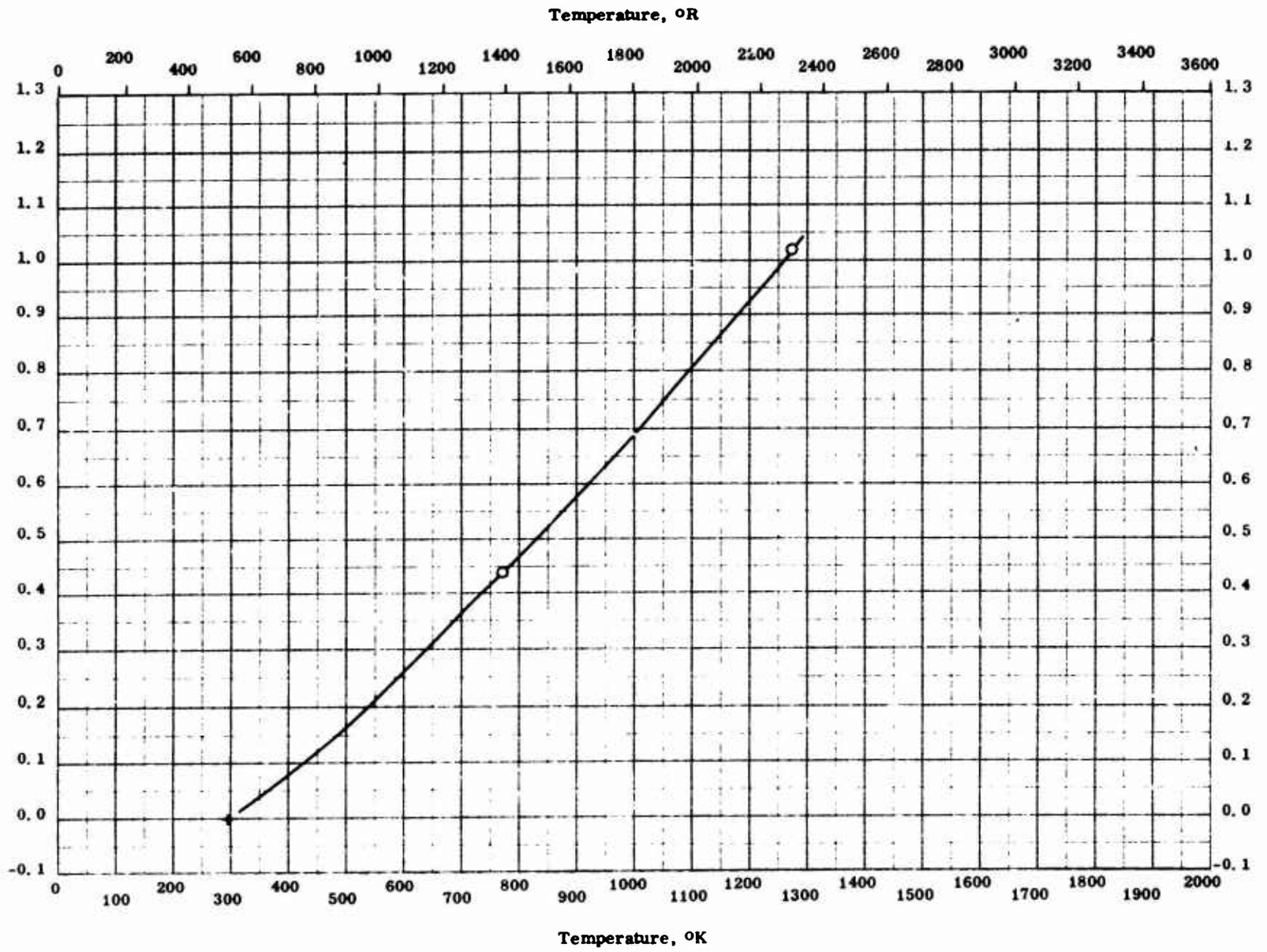
SPECIFIC HEAT -- CADMIUM OXIDE

SPECIFIC HEAT -- CADMIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	65-1	300-1000	1.3	99.9525 CdO.	

TPRC



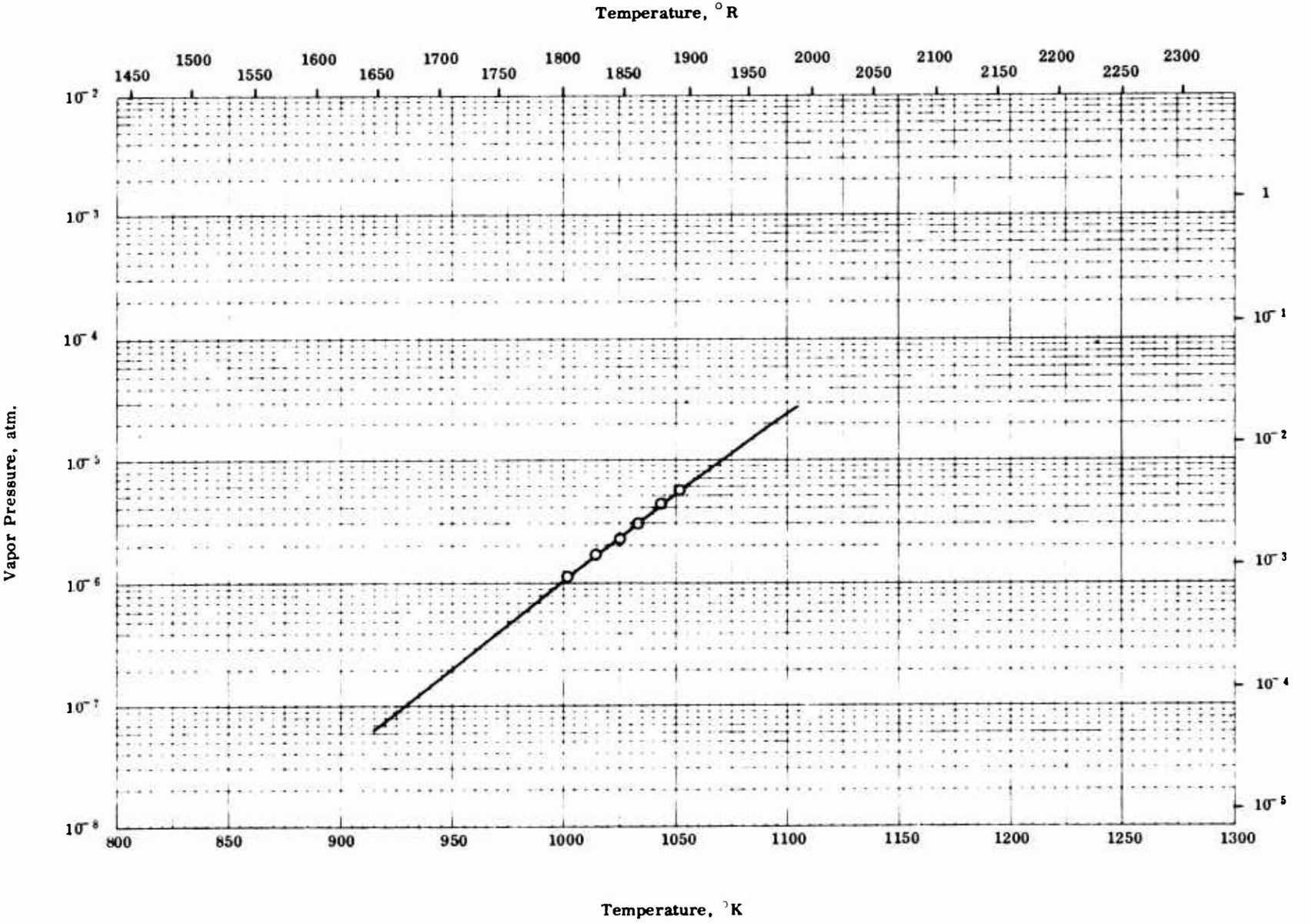
THERMAL LINEAR EXPANSION -- CADMIUM SESQUIOXIDE

THERMAL LINEAR EXPANSION -- CADMIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	60-35	298-1273		Cd_2O_3.	

TPRC



VAPOR PRESSURE -- CADMIUM OXIDE

VAPOR PRESSURE -- CADMIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	41-1	1003-1053		CdO.	

PROPERTIES OF CALCIUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	3.35	207
Melting Point	2903	5225

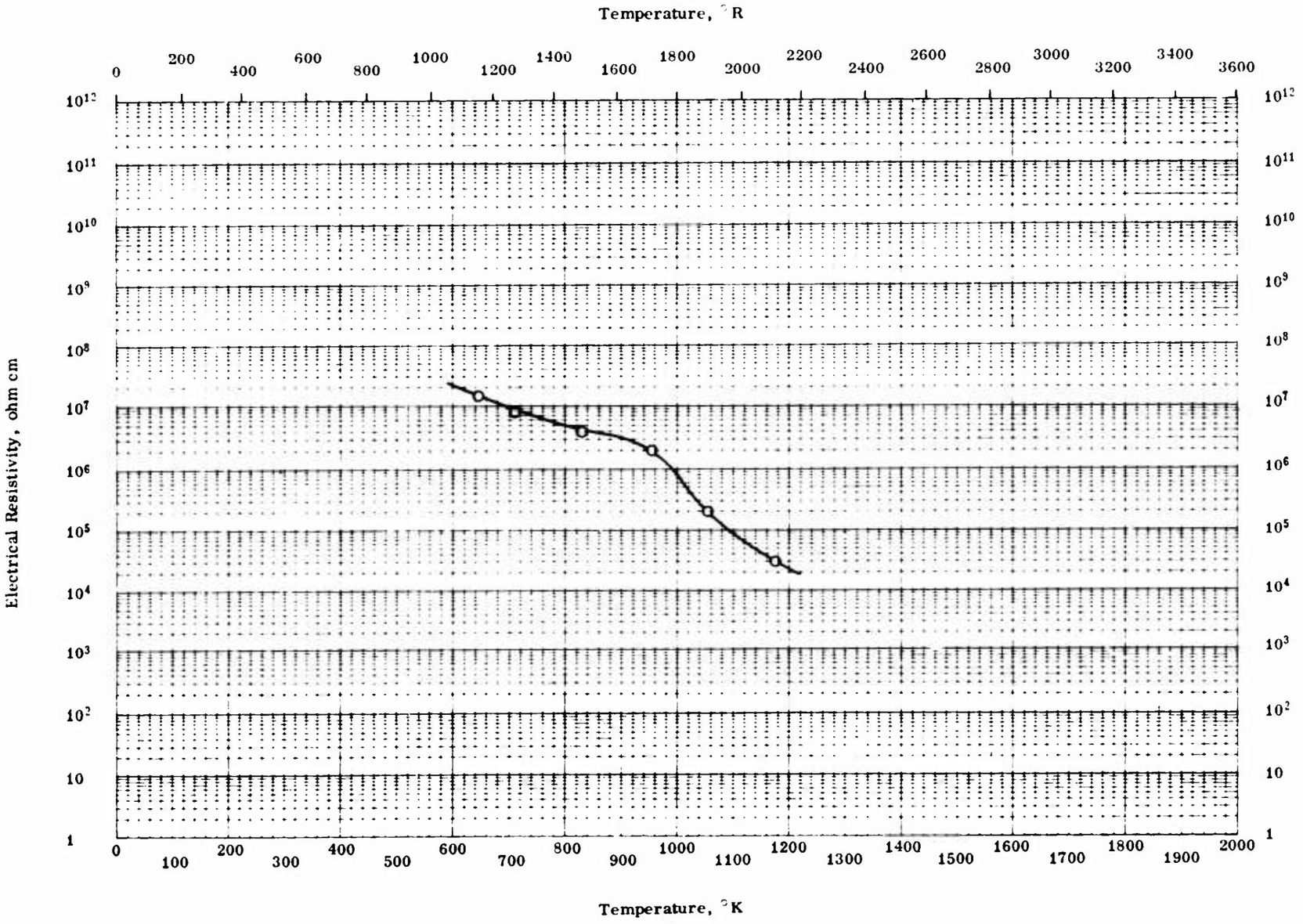
REPORTED VALUES

Density		$g\ cm^{-3}$	$lb\ ft^{-3}$
	○	3.0	187
	□	1.74	109
Melting Point		K	R
	△	2843	5117
	▽	2903	5225
	◇	~2843	~5117

PROPERTIES OF CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error σc	Sample Specifications	Remarks
○	55-24	298		Dense material made from high purity calcium carbonate.	Density from weight and volume by mercury displacement.
□	55-24	298		Same as above except light material.	Same as above.
△	49-3	2843			
▽	62-17	2903			
◇	62-18	2843			

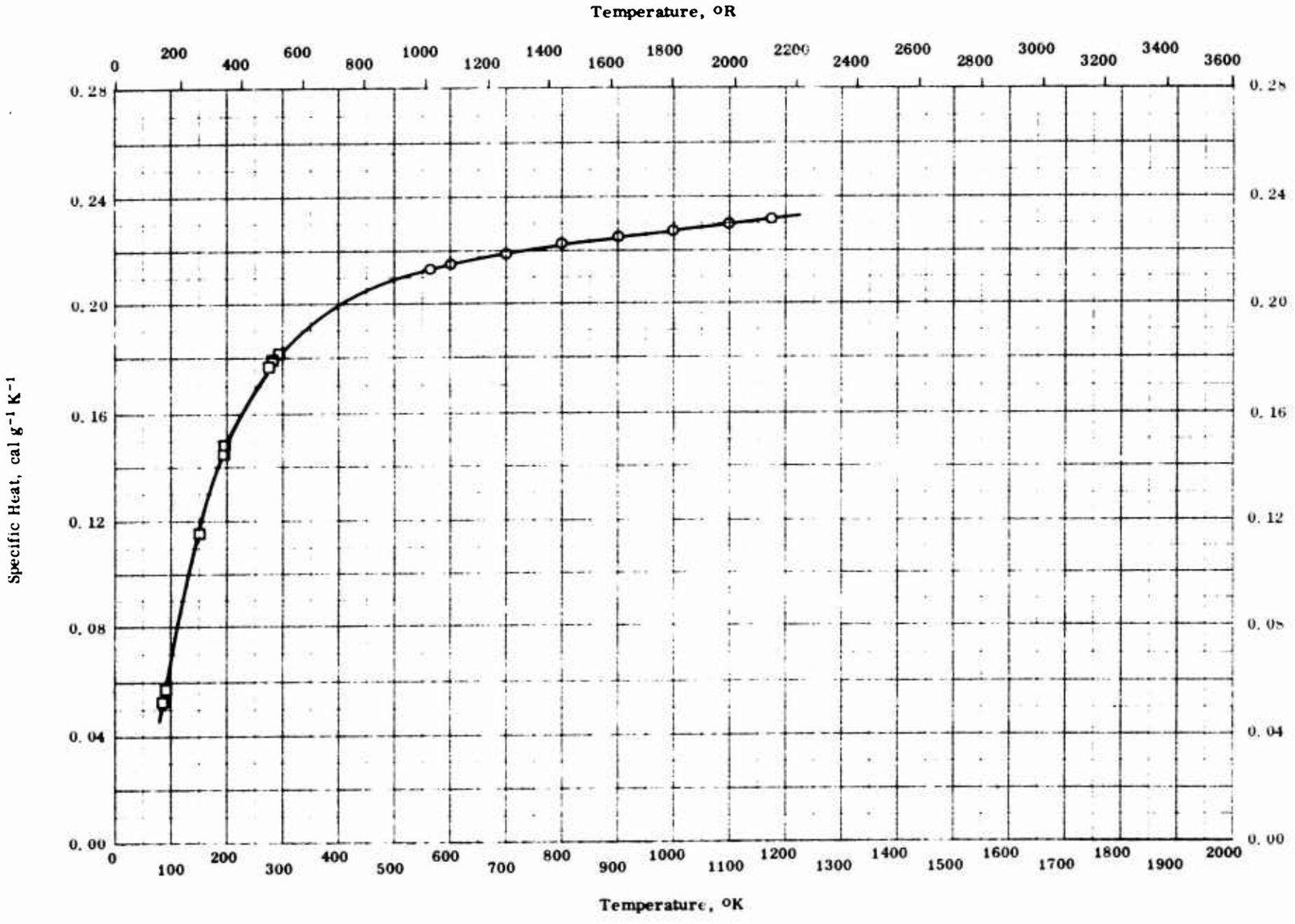


ELECTRICAL RESISTIVITY -- CALCIUM OXIDE

ELECTRICAL RESISTIVITY -- CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	56-13	645-1178		CaO; polycrystal; prepared from chemically pure materials.	Calcined 2 hrs at 0.46 of MP.



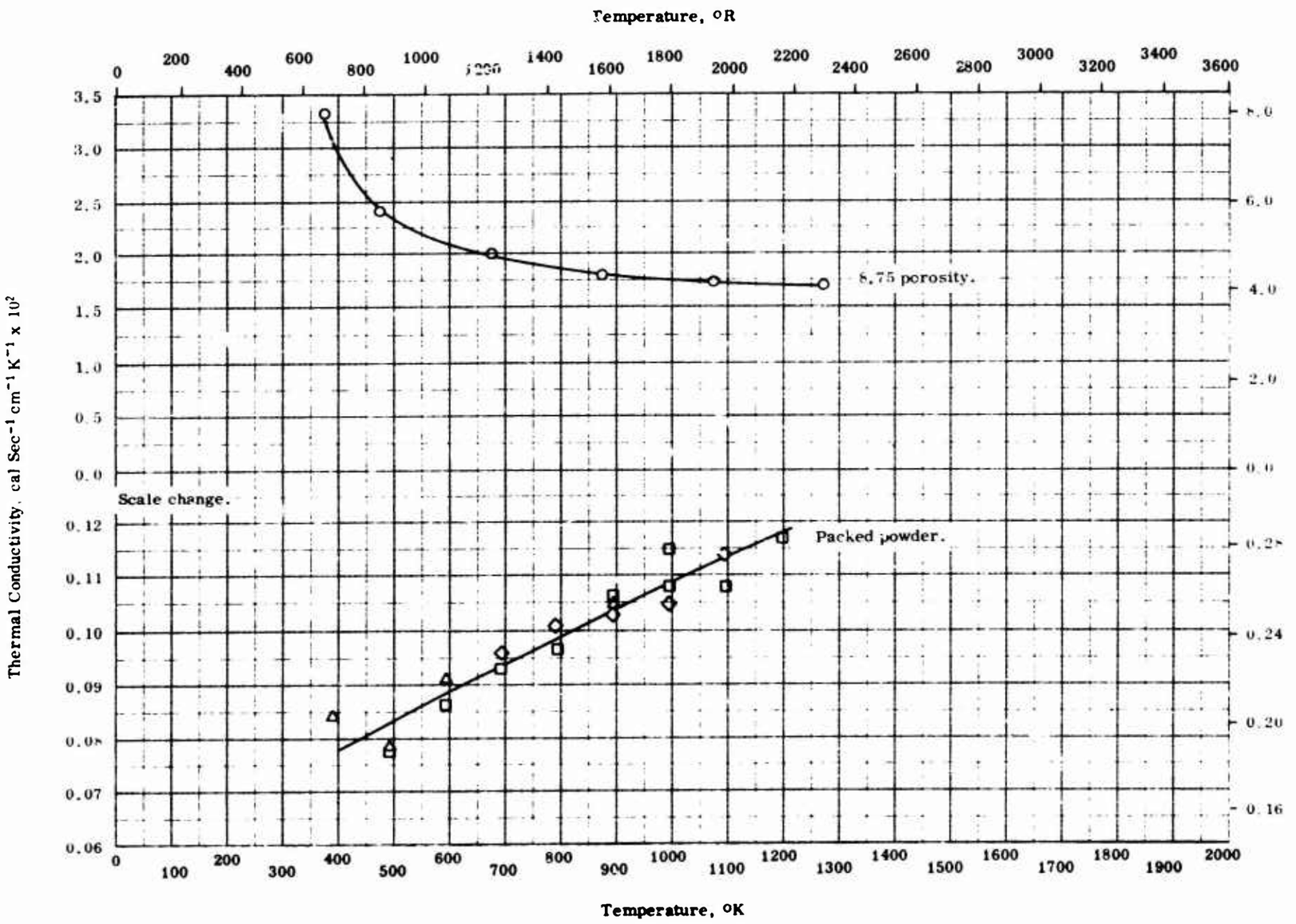
SPECIFIC HEAT -- CALCIUM OXIDE

SPECIFIC HEAT -- CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	51-10	563-1176	0.10	High purity.	Calcined at 800 C.
□	26-1	87-293	1.0	98.8 CaO and 0.4 H_2O.	

TPRC

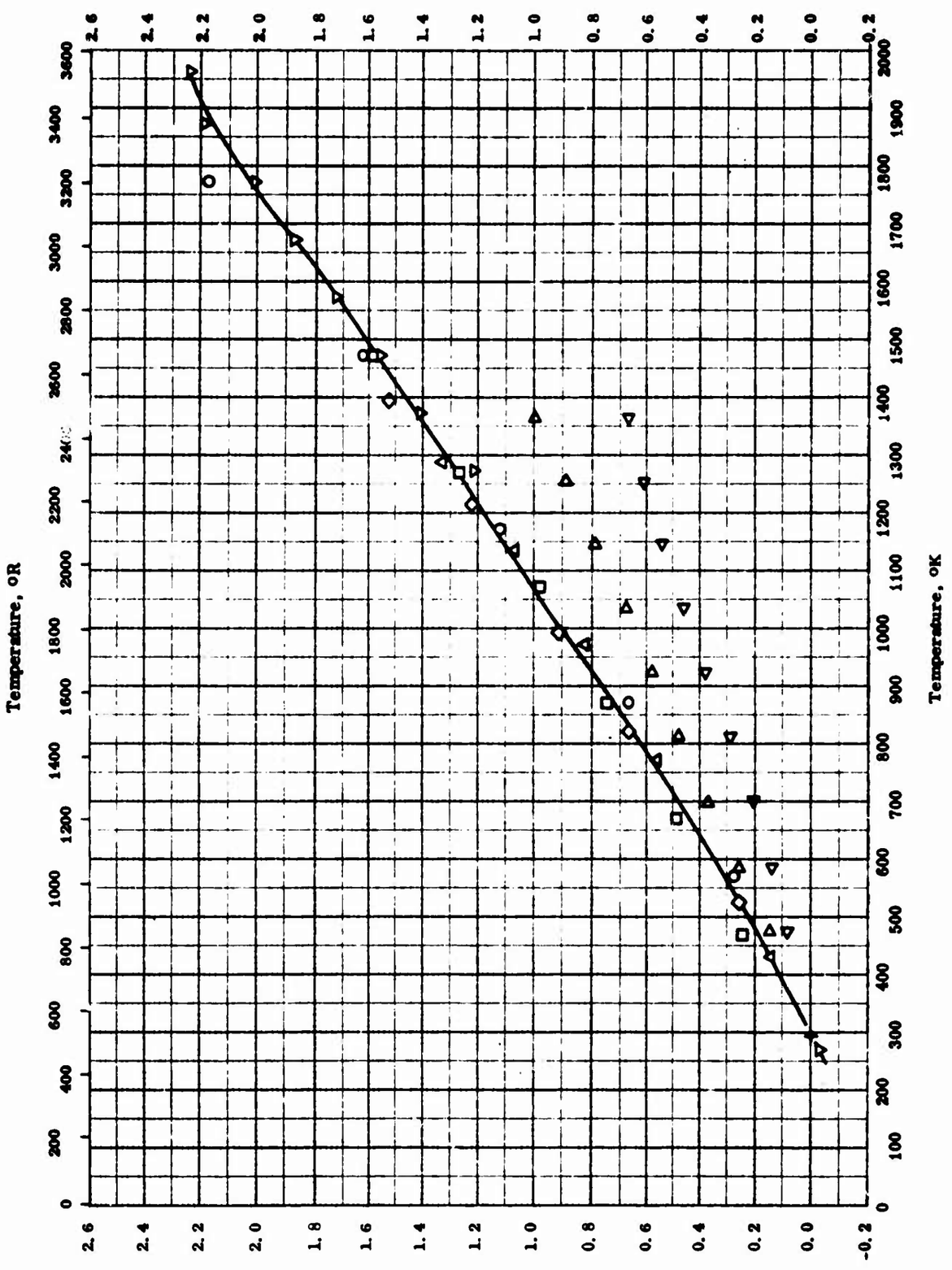


THERMAL CONDUCTIVITY -- CALCIUM OXIDE

THERMAL CONDUCTIVITY -- CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-1	373-1273		Density 3.03 g cm^{-3} and porosity 8.75%.	Prepared by calcining c.p. $CaCO_3$ at 1600 C and pressing; fired at 1900 C.
△	59-4	390-897	6	Powdered lime having 90% particle sizes in 0.3 - 6.6 micro range, packing density 1.86 g cm^{-3}.	Packed.
□	59-4	494-1199	6	Same as above; except packing density 1.57 g cm^{-3}.	Packed.
◇	59-4	693-1197	6	Same as above.	Packed.

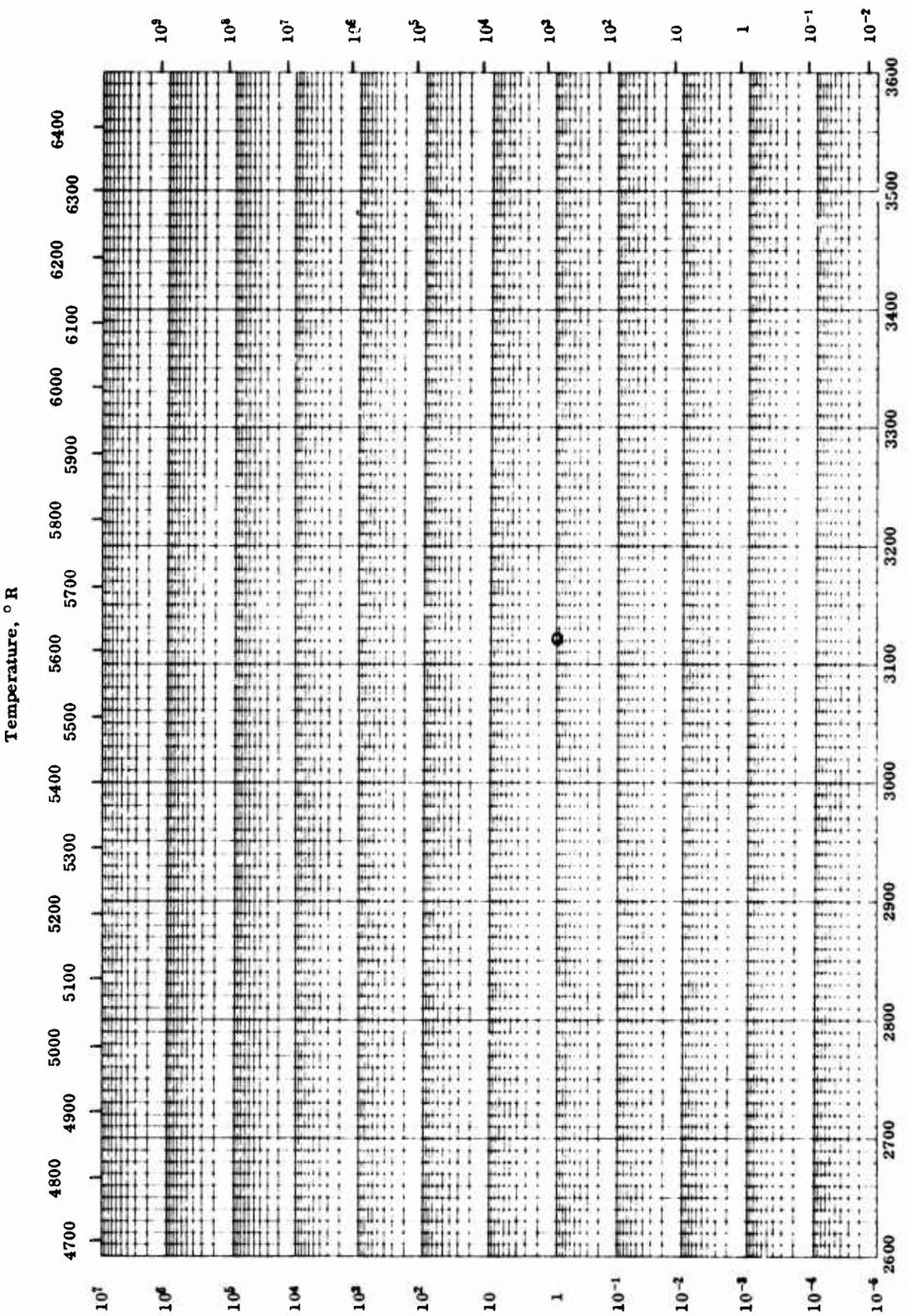


THERMAL LINEAR EXPANSION -- CALCIUM OXIDE

THERMAL LINEAR EXPANSION -- CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◇	62-28	302-1398	2-3	Reagent quality CaO: 0.1 - 1 Al, Mg, S, 0.03 - 0.3 Fe, 0.01 - 0.1 Na, 0.003 - 0.03 Ti, trace of B, Cr, Cu, Mn, and V; cubic structure.	Mixture of 60 CaO and 40 Pt powder ground together, fired at 1400 C in air for 5 hrs, cooled under desiccation, and reground; Pt powder used for furnace alinement and thermal calibration; x-ray diffractometer method.
▽	64-18	273-1973		Pure CaO prepared from chemically pure $CaCO_3$.	Fired at 1350-1400 C, ground for 5 hrs in steel ball mill to grain size of 1-2 μ, pressed at 1000 kg cm^{-2}, and fired at 1750 C for 2 hrs; measured in vacuum.
▷	61-40	297-1366		Stabilized CaO; 100% cubic structure.	Pressed and sintered rod.
◁	61-40	297-1366		Stabilized CaO; cubic plus at least 5% monoclinic structure.	Plasma flame sprayed zirconia powder.
○	56-28	293-1773		Coarse fused grain CaO.	
□	57-34	293-1473		Reagent grade CaO.	X-ray back reflection method.
△	54-33	433-1288		CaO.	



VAPOR PRESSURE -- CALCIUM OXIDE

VAPOR PRESSURE -- CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	49-3	3123		CaO.	

PROPERTIES OF CERIUM OXIDES

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	7.10*	443*
Melting Point	3073*	5532*

*For CeO_2 only

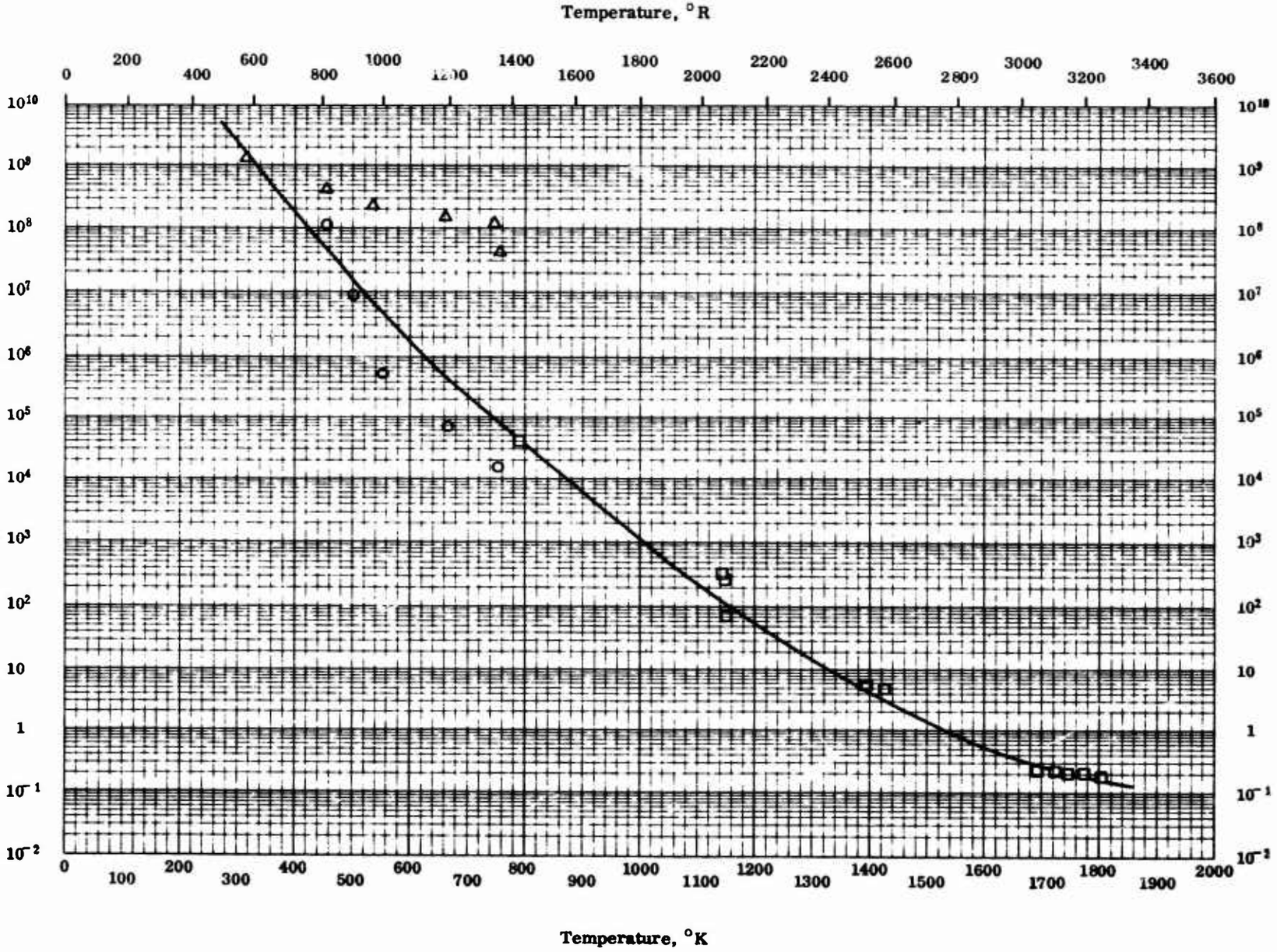
REPORTED VALUES

Density	g cm^{-3}	lb ft^{-3}
○ CeO_2	7.10	443
△ Ce_2O_3	6.867	428.5
▽ CeO	7.77	484.8
Melting Point	**K**	**R**
□ CeO_2	3073	5532

PROPERTIES OF CERIUM OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-27	298		CeO_2.	
□	49-3	3073		CeO_2.	
△	62-16	298		Ce_2O_3.	
▽	62-16	298		CeO.	



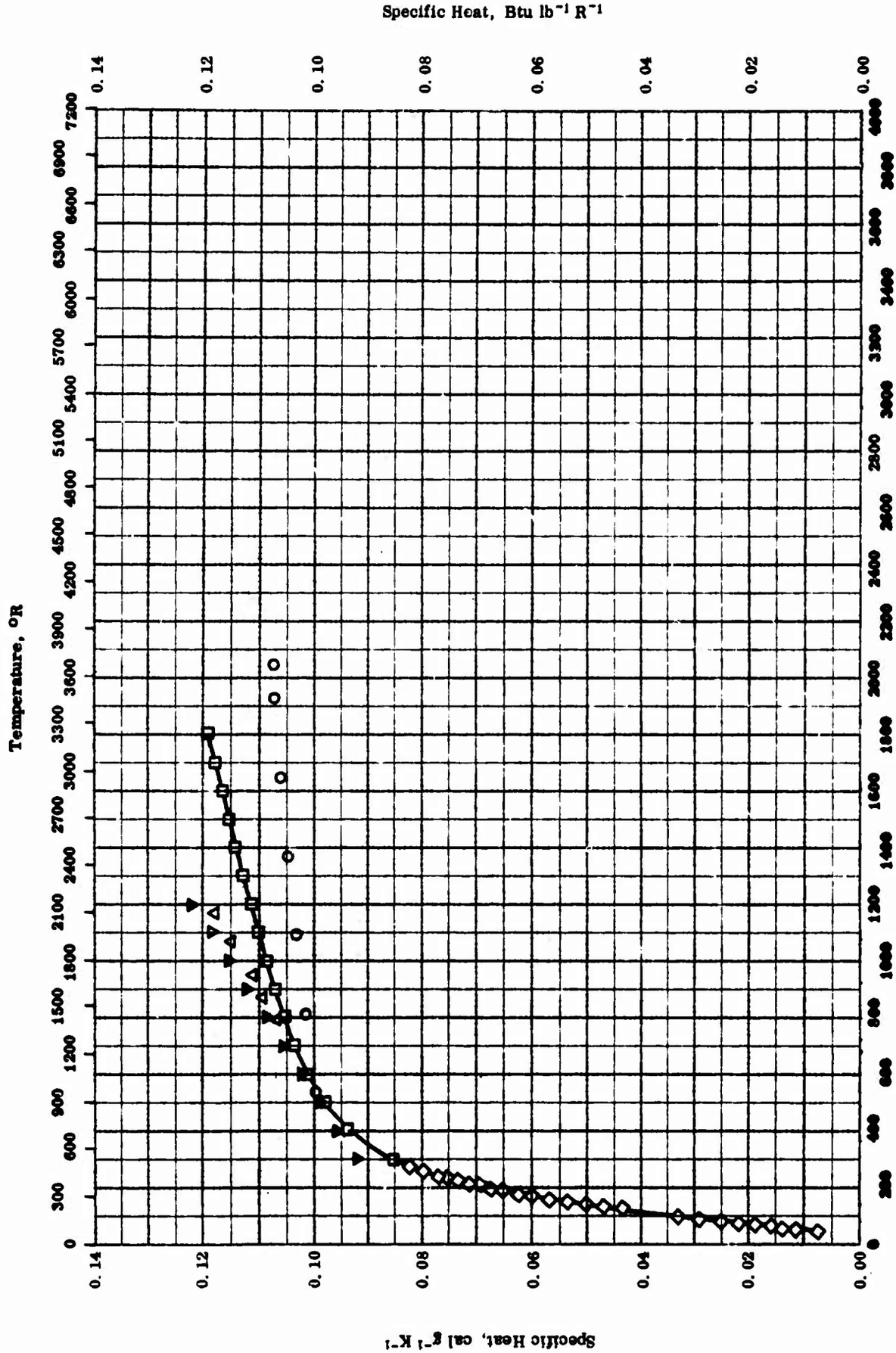
Electrical Resistivity, ohm cm

ELECTRICAL RESISTIVITY -- CERIUM DIOXIDE

ELECTRICAL RESISTIVITY -- CERIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	57-17	317-758		CeO_2; column purified powder.	Compacted in hand screwed apparatus; auth. states values are inaccurate; values sensitive to partial pressure of oxygen; heating curve.
△	57-17	317-758		CeO_2.	Same as above; cooling curve.
□	62-4	791-1805	2.4	CeO_2; 82.2 Ce.	Pressed and sintered; max. exposure temperature 3800 F.



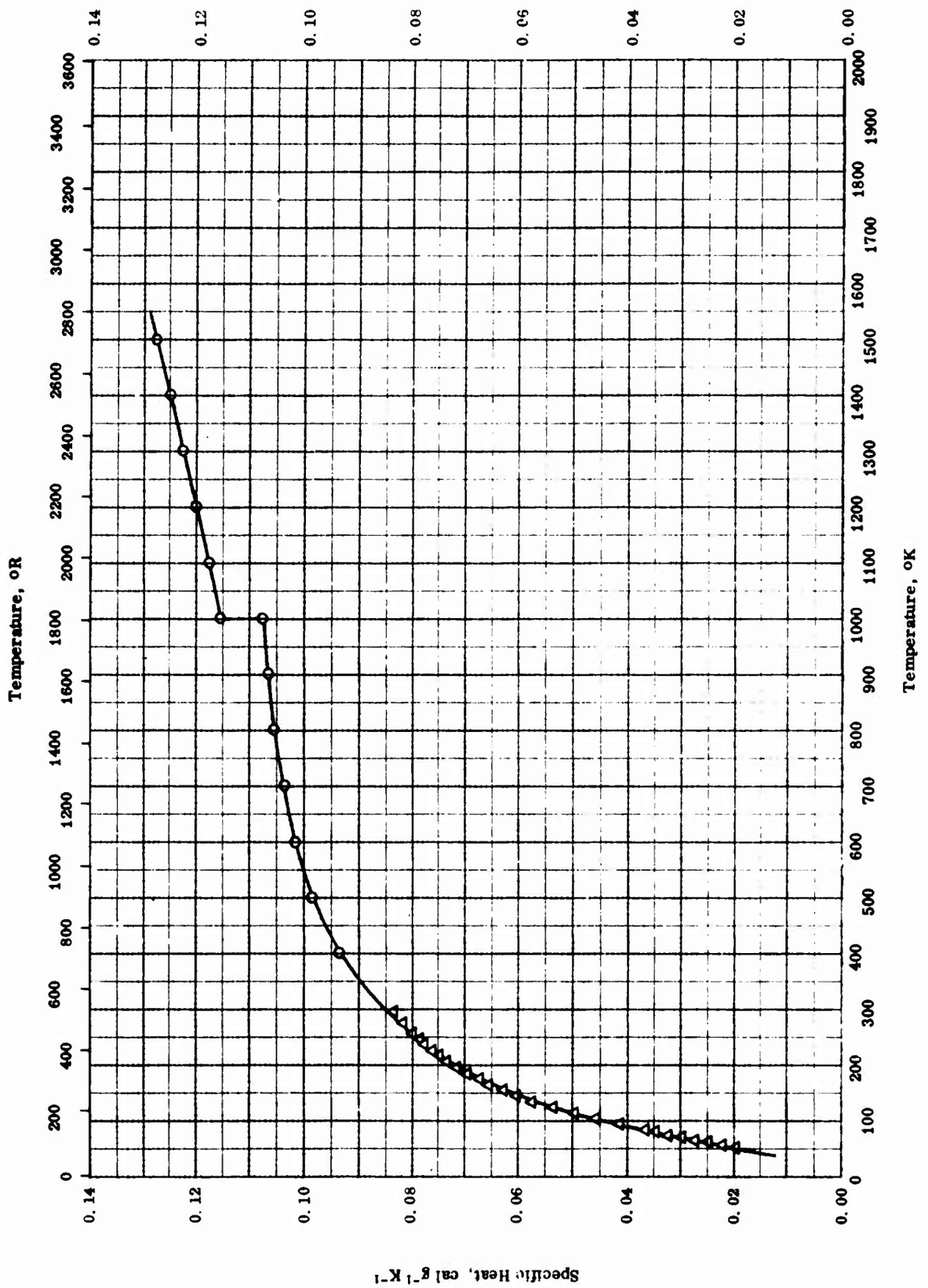
SPECIFIC HEAT -- CERIUM DIOXIDE

SPECIFIC HEAT -- CERIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-4	533-2044	≤5.0	Before test: 82.2 Ce, 0.2 Zr, and 0.1 Ca; density 329 lb ft^{-3}; and after test: 81.5 Ce, and 0.10 C; density 422 lb ft^{-3}.	Crushed in hardened steel mortar to pass 100-mesh screen, pressed and sintered.
□	61-14	298-1800	0.2	99.9 CeO_2.	Heated at 1050 C for one hr.
△	60-11	608-1172	0.2	99.9 CeO_2.	
◇	61-20	5-300	0.1-10	99.98 CeO_2.	Prepared by precipitating cerium hydroxide using gaseous ammonia and igniting in air to dioxide at 1000 C for 72 hrs.
▽	65-1	300-1200	0.5	Spectroscopically pure.	

TPRC

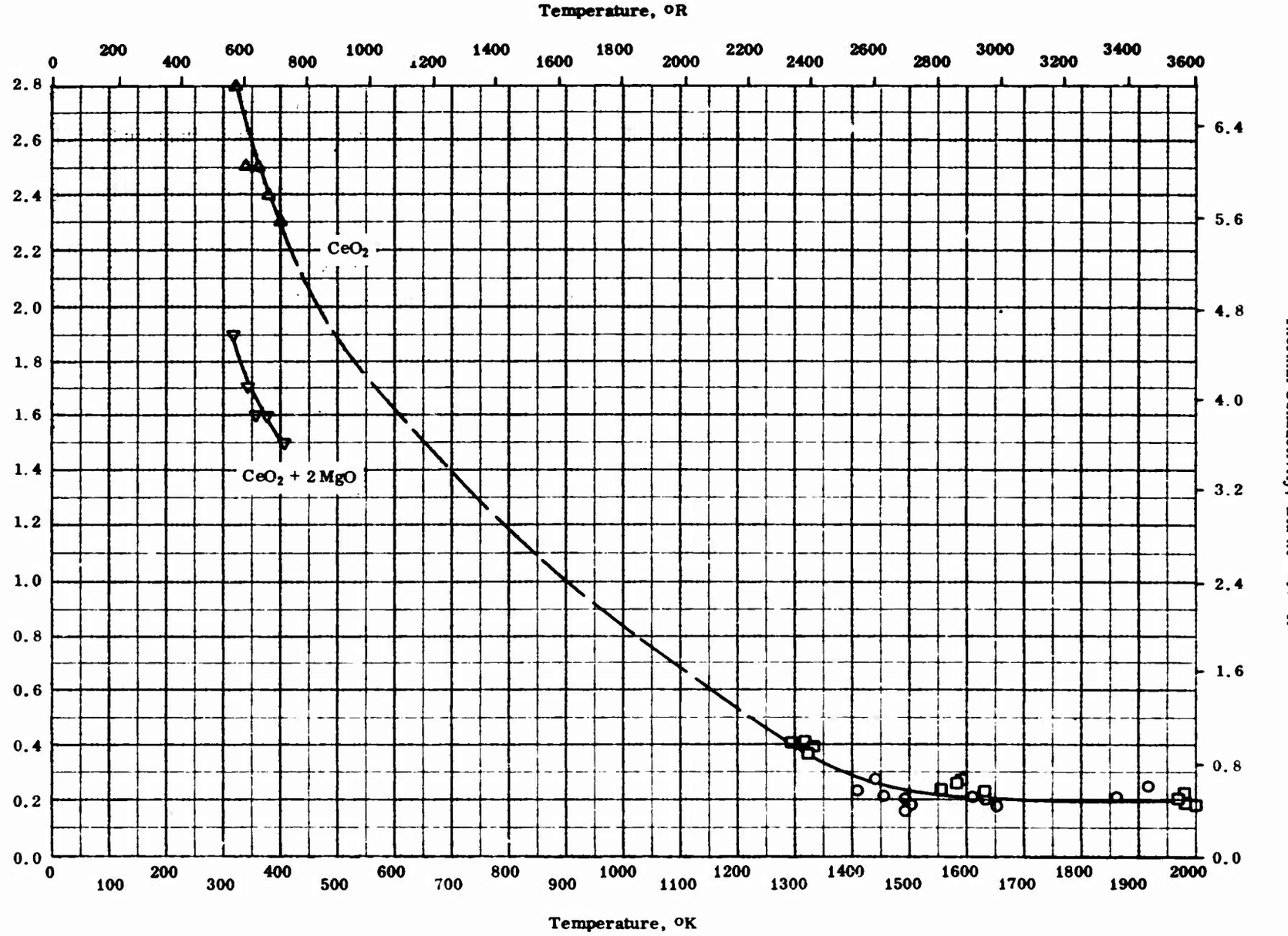


SPECIFIC HEAT -- CERIUM (OUS) OXIDE

SPECIFIC HEAT -- CERIUM (OUS) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-20	50-298	0.10	$Ce_2O_{3.33}$; 0.02 Al_2O_3 and 0.002 > C.	Under nitrogen atmosphere.
Δ	62-14	298-1800		Ce_2O_3; 99.9 Ce_2O_3, 0.02 Al_2O_3, and 0.001 C.	

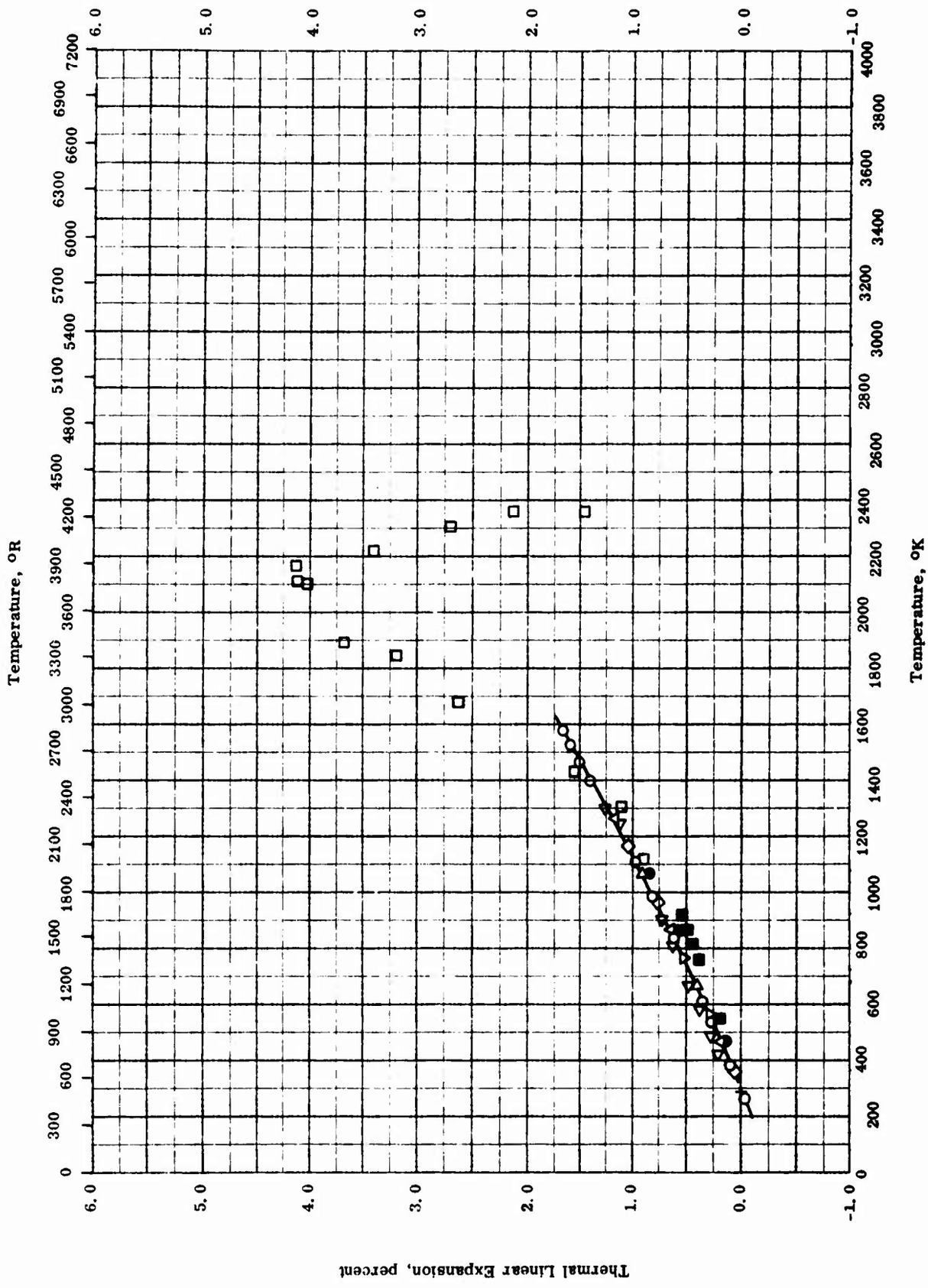


THERMAL CONDUCTIVITY -- CERIUM DIOXIDE

THERMAL CONDUCTIVITY -- CERIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
△	52-4	320-397		CeO_2 ; density 6.20 g cm^{-3} and 0.0042% water absorption.	Fired at 2700 F; with buff color.
▽	52-4	317-404		98 CeO_2 and 2 MgO; density 5.58 g cm^{-3} and 0.59% water absorption.	Fired at 2850 F; with buff color.
○	62-4	1410-1915		CeO_2.	Ground and then polished thoroughly; sample found broken on post imspection.
□	62-4	1292-2006		CeO_2.	Same as above; sample found cracked on post inspection.



THERMAL LINEAR EXPANSION -- CERIUM DIOXIDE

THERMAL LINEAR EXPANSION -- CERIUM DIOXIDE

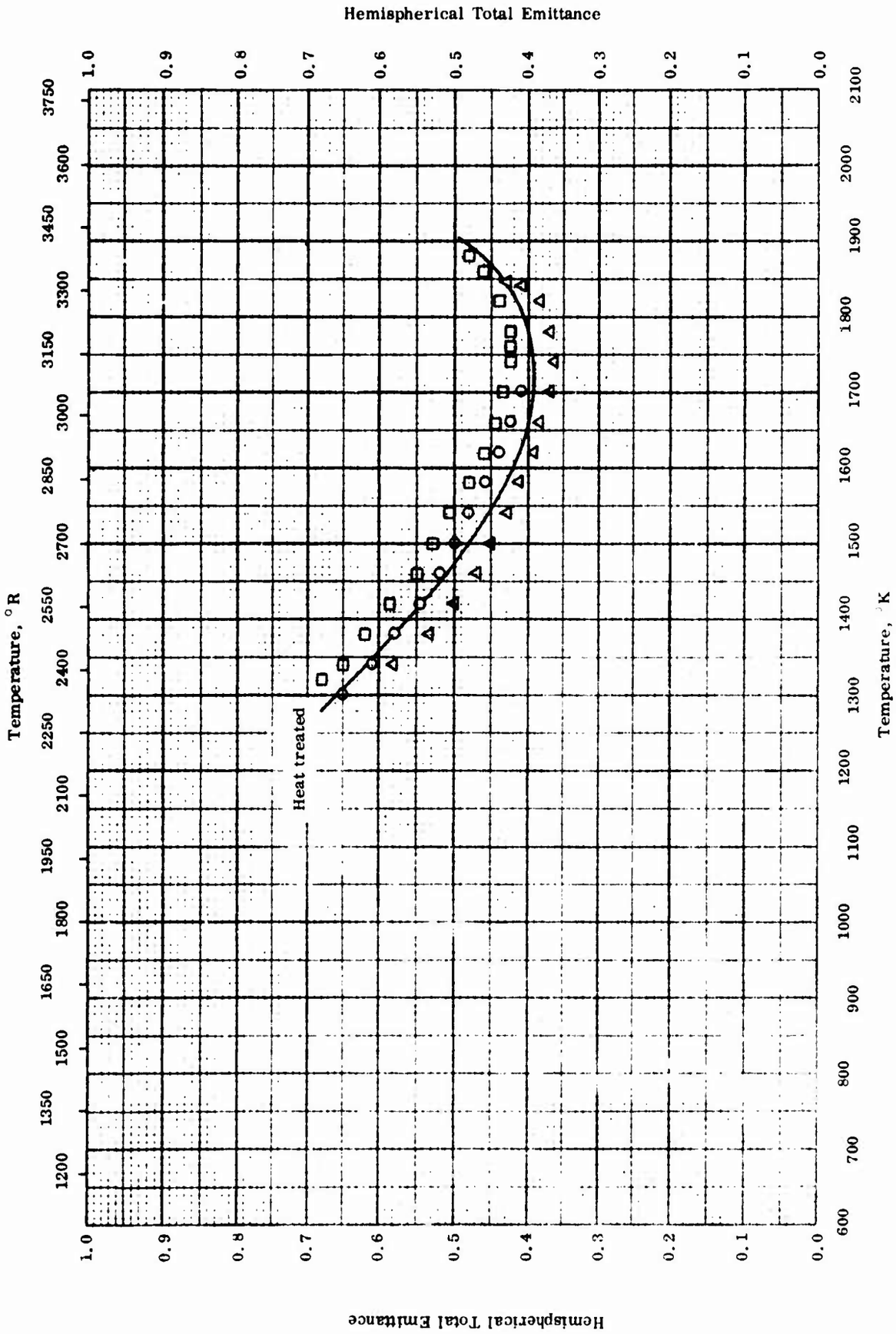
REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-41	273-1583	1.1-6.0	CeO_2, code 215 from Lindsay Chemical Co., West Chicago, Ill.; 99.9 CeO_2 in regard to total rare-earth content; 0.1 - 1.0 Th, 0.001 - 0.01 Al, Ca, Cu, Dy, Er, and Pr, trace of Fe, Gd, Lu, Mg, Tm, and Y.	Sintered at 1350 C for 24 hrs, packed into alumina sample holder, resintered at 1450 C for 12 hrs, cooled to 300 C, and placed in vacuum desiccatar for storage; x-ray diffractometer method.
□	62-4	294-2366	5	CeO_2 from Zirconium Corp. of Am.; 82.2 Ce; elements found by semi-quantitative emission spectrography before exposure 0.2 Zr and 0.1 Ca; after exposure 81.5 Ce and 0.10 C; density in g cm^{-3} at 25 C by ASTM method B311-58 before exposure 6.60, after exposure 6.57; initial length 2.934 in. [Author's design : Run No. E 14]	Pressed and sintered; measured in helium atm; sample melted on post inspection.
◇	63-35	298-1273		CeO_2; 0.1 - 1.0 Th, 0.001 - 0.01 Al, Ca, Cu, Dy, Er, Gd, Lu, Pr, Si, Tm, Y, and 0.0003 - 0.003 Fe and Mg; cubic structure; bulk density after expansion run measured by mercury displacement at low pressure 6.4 g cm^{-3}.	Precalcined at 1200 C for approx 1 hr, mixed with binder (2% Varsol plus 2% paraffin dissolved in benzene), hot pressed to 1400 C at approx 2600 psi, ground into shape, matured at 1400 C overnight, heated to 1500 C for 1 hr, and desiccated; heating rate approx. 5 C min^{-1}.
△	63-35	298-1273		Same as above.	Second run of above sample.

(Continued onto next page)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▽	63-35	298-1272		CeO_2; 0.03 - 0.3 Dy, 0.01 - 0.1 Na, Th, 0.003 - 0.03 Mg, Si, 0.001 - 0.01 Lu, Y, and 0.0001 - 0.001 Yb; cubic structure; bulk density after expansion run measured by mercury displacement at low pressure 5.1 g cm^{-3}.	Powder mixed with 4% binder (approx. 10% polyvinyl alcohol solution), dry pressed at 19,000 psi, heated to 225 C for 2 hrs to burn off binder, heated to 1000 C for 16 hrs, further heated to 1450 C for 1 hr, ground into shape, matured at 1500 C for approx. 1 hr, and desiccated; heating rate approx. 5 C min^{-1}.
△	63-35	298-1274		Same as above.	Second run of above sample.
◁	62-34	304-1301		CeO_2 from Johnson Matthey and Co., London; spectroscopically pure.	X-ray diffraction method.
●	62-24	298-1273		Prepared from 99.9 CeO_2 from Research Chemical Corp.; particle size approx. 5μ; 96.5% theoretical density.	Particle size reduced to less than 1μ in fluid energy mill, hot pressed for 45 min at 10,000 psi and 1150 C; two samples welded together by hot pressing as above.
■	46-6	293-923		Ceria.	

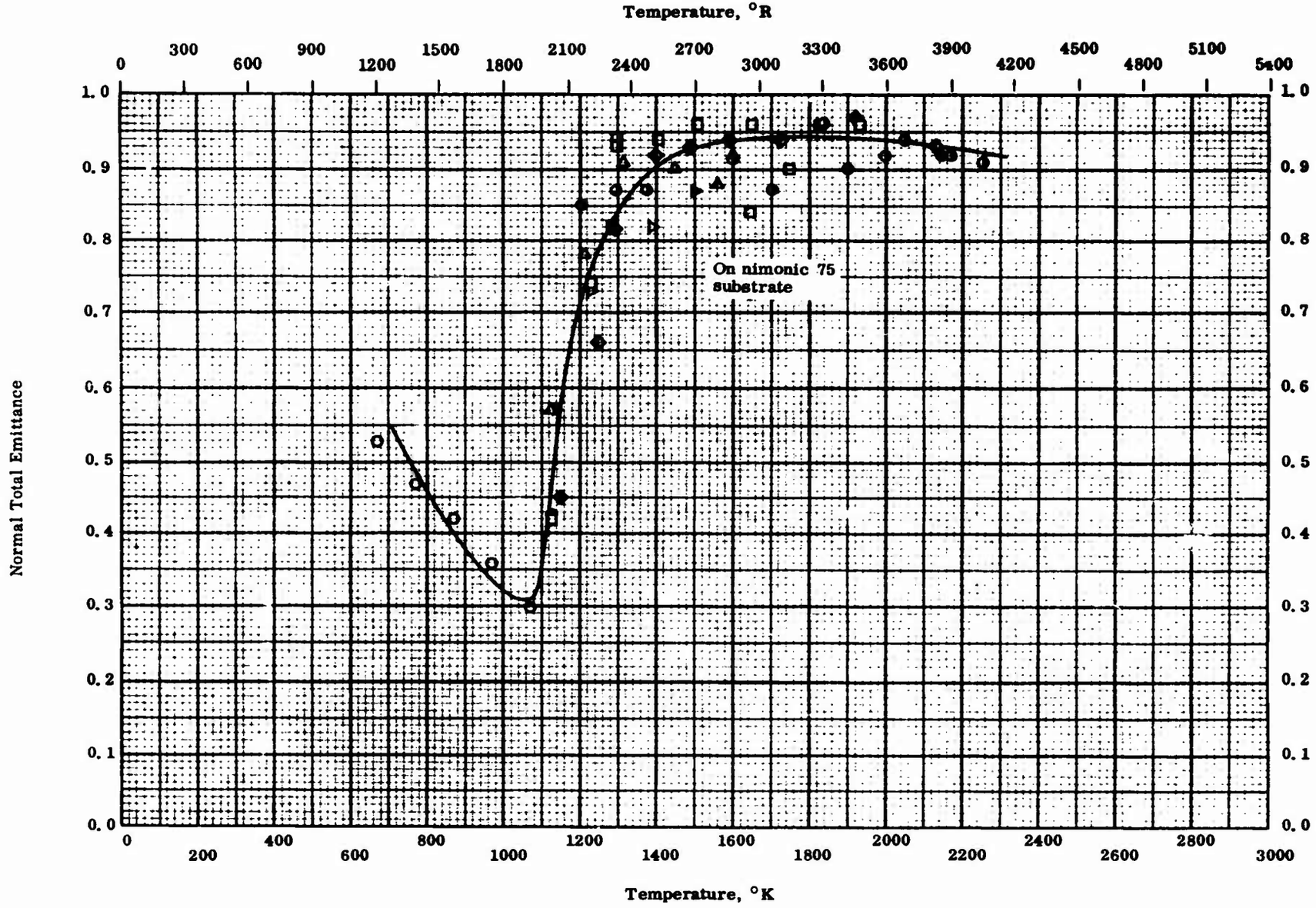


HEMISPHERICAL TOTAL EMITTANCE -- CERIUM DIOXIDE

HEMISPHERICAL TOTAL EMITTANCE -- CERIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-16	1300-1700		CeO_2, commercial grade; 50 μ deposit on tungsten rod.	Heat treated at less than 1750 K; measured in vacuum; opacity of deposit reported questionable; data taken from smooth curve.
△	52-16	1340-1845		Same as above.	Same as above.
□	52-16	1320-1880		Same as above.	Same as above except heat treated above 1750 K.

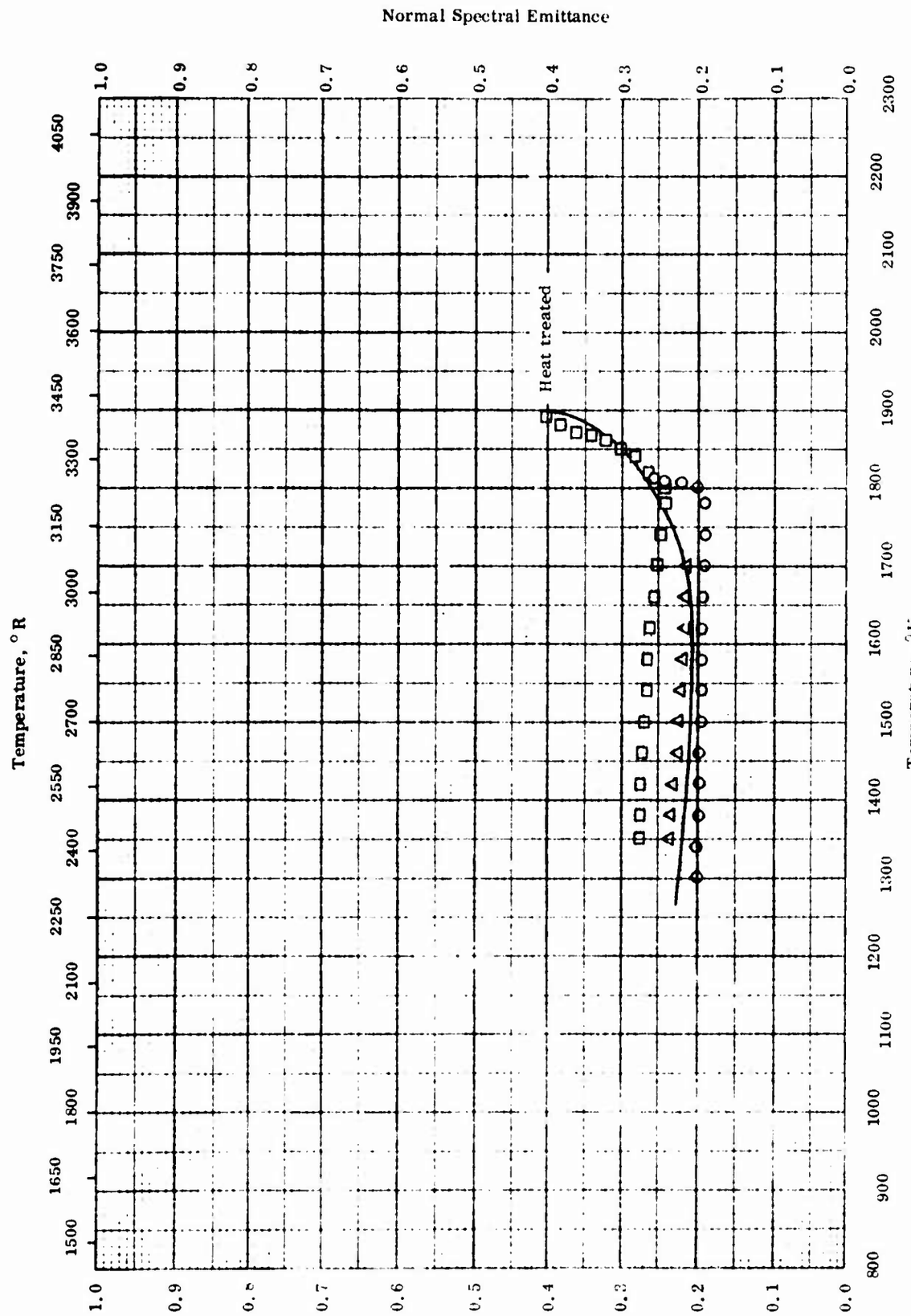


NORMAL TOTAL EMITTANCE -- CERIUM DIOXIDE

NORMAL TOTAL EMITTANCE -- CERIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-17	673-1073		CeO_2, powder coating on Nimonic 75 strip.	Measured in air.
△	62-4	1122-1599	10	CeO_2; density 6.87 gcm^{-3}.	Pressed and sintered; measured in dry argon atmosphere; run No. 1.
□	62-4	1127-1933	10	Same as above.	Same as above; run No. 2.
◉	62-4	1127-2255	10	Same as above.	Same as above; run No. 3.
▷	62-4	1133-1499	10	Same as above.	Same as above; run No. 4.
◈	62-4	1143-2133	10	Same as above.	Same as above. run No. 5.

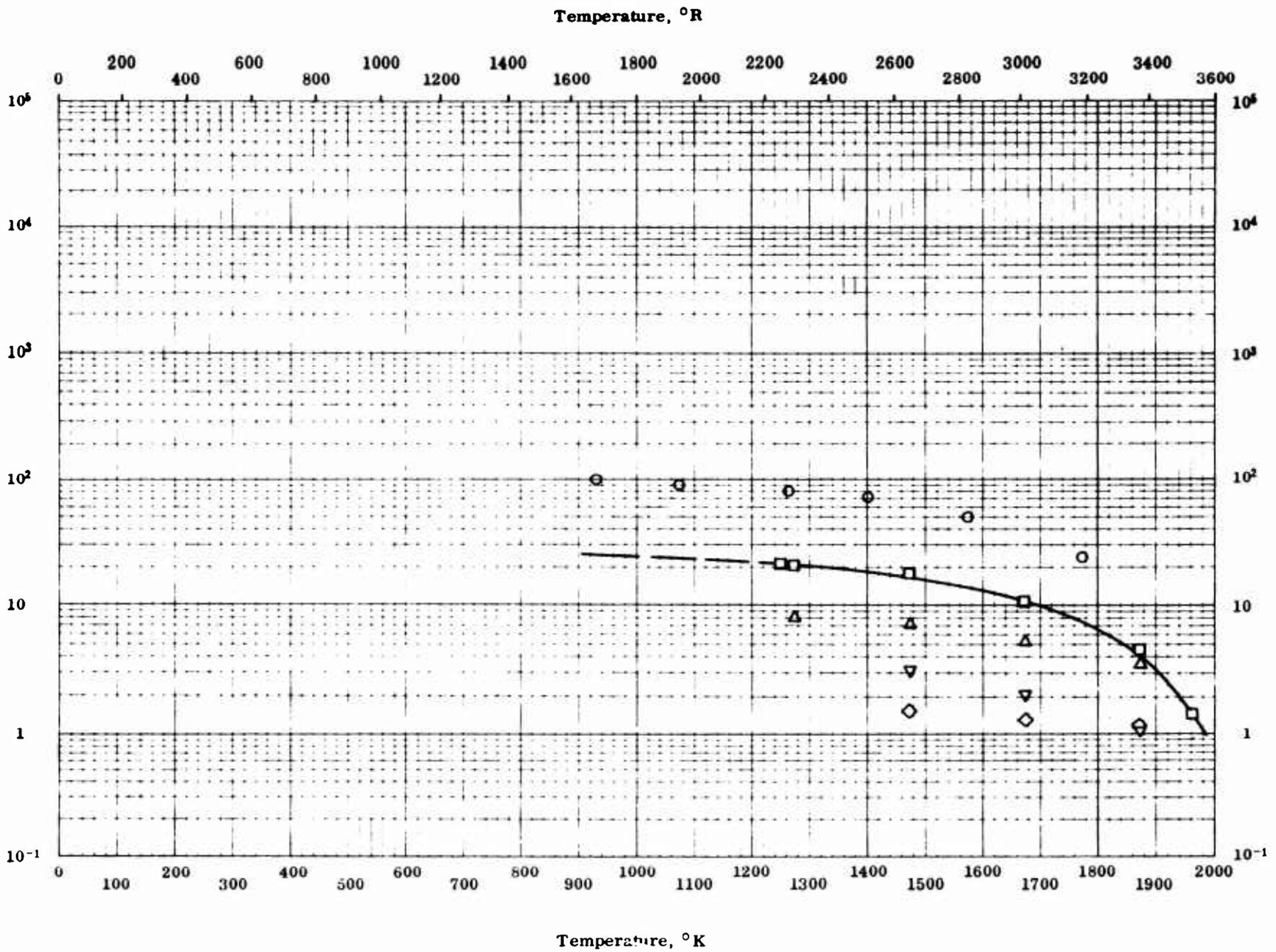


NORMAL SPECTRAL EMITTANCE -- CERIUM DIOXIDE

NORMAL SPECTRAL EMITTANCE -- CERIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Wavelength μ	Temp. Range ° K	Rept. Error%	Sample Specifications	Remarks
○	52-16	0.665	1300-1810		CeO_2, commercial grade; 50μ deposit.	Heat treated at less than 1750 K; measured in vacuum; opacity of deposit reported questionable.
△	52-16	0.665	1350-1700		Same as above.	Same as above.
□	62-16	0.665	1350-1890		Same as above.	Same as above except heat treated above 1750 K.

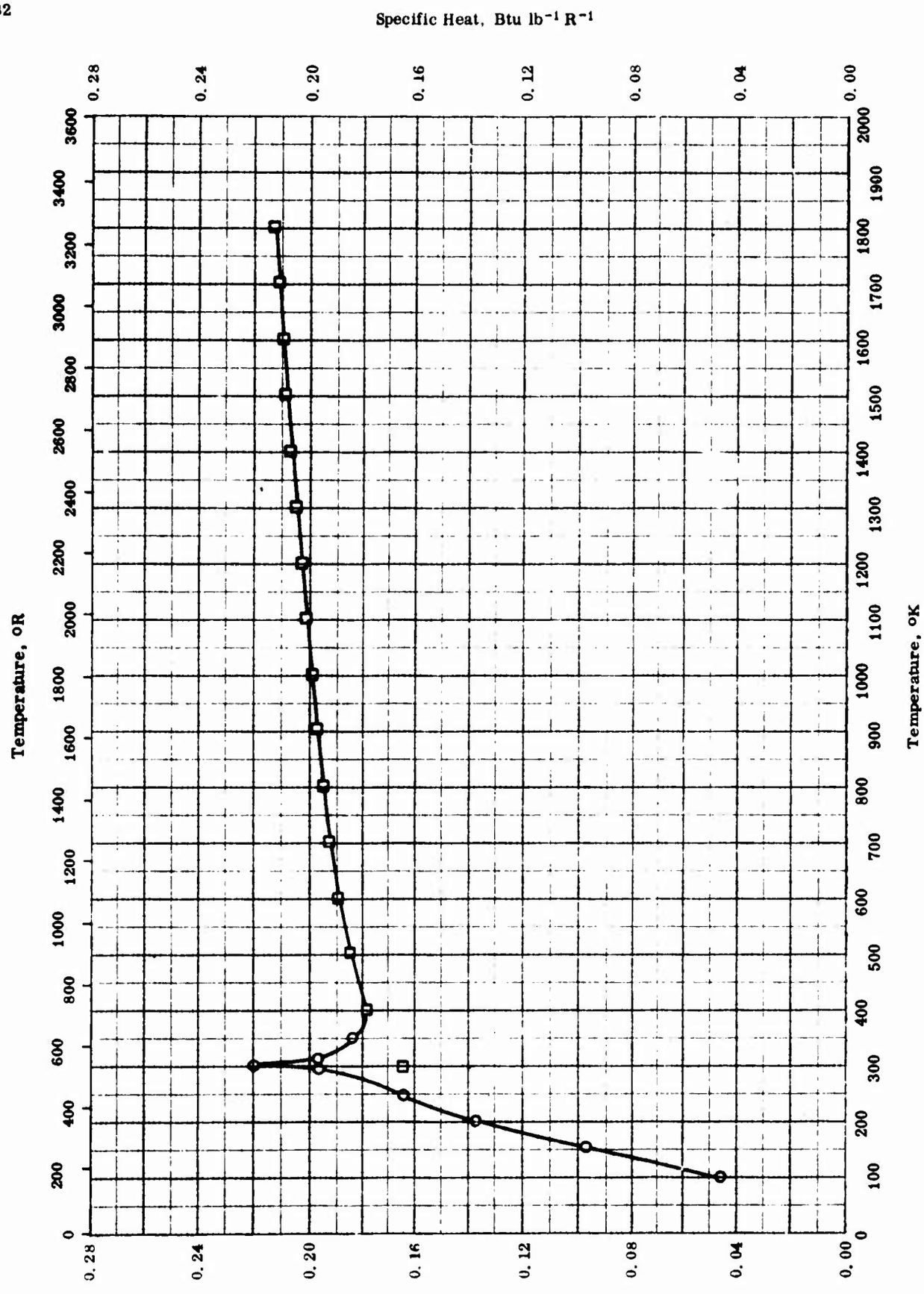


ELECTRICAL RESISTIVITY -- CHROMIUM SESQUIOXIDE

ELECTRICAL RESISTIVITY -- CHROMIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-17	933-1773		100 Cr_2O_3.	Fired at 1450 C for 10 hrs; poorly sintered.
□	57-16	1250-1961		Water free; 0.5 alkalies, 0.055 Fe, 0.037 Ca, 0.023 Mg, 0.010 Si, and no trace Al.	Presintered 1 hr at 1500 C in argon atmos; results independent of frequency.
△	57-16	1273-1873		Same as above with 0.9 Cu_2O added to □ .	Same as above.
▽	57-16	1473-1873		Same as above with 0.5 TiO_2 added to □ .	Same as above.
◇	57-16	1473-1873		Same as above with 0.7 TiO_2 added to □ .	Same as above.

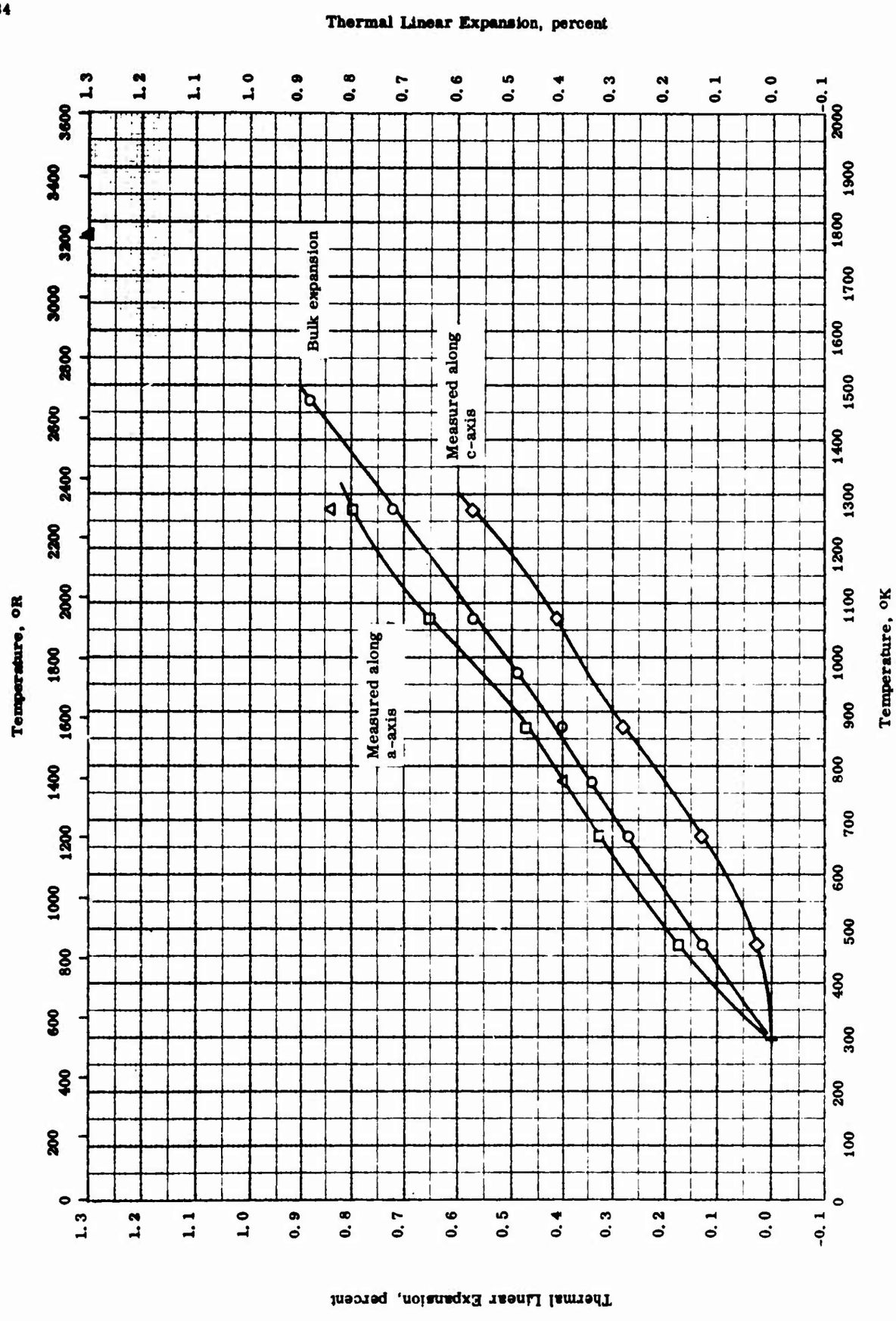


SPECIFIC HEAT -- CHROMIUM SESQUIOXIDE

SPECIFIC HEAT -- CHROMIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-10	100-350		Cr_2O_3.	Prepared by firing ammonium dichromate in air at 1000 C, formed solid piece.
□	44-2	298-1800	0.4	Cr_2O_3.	

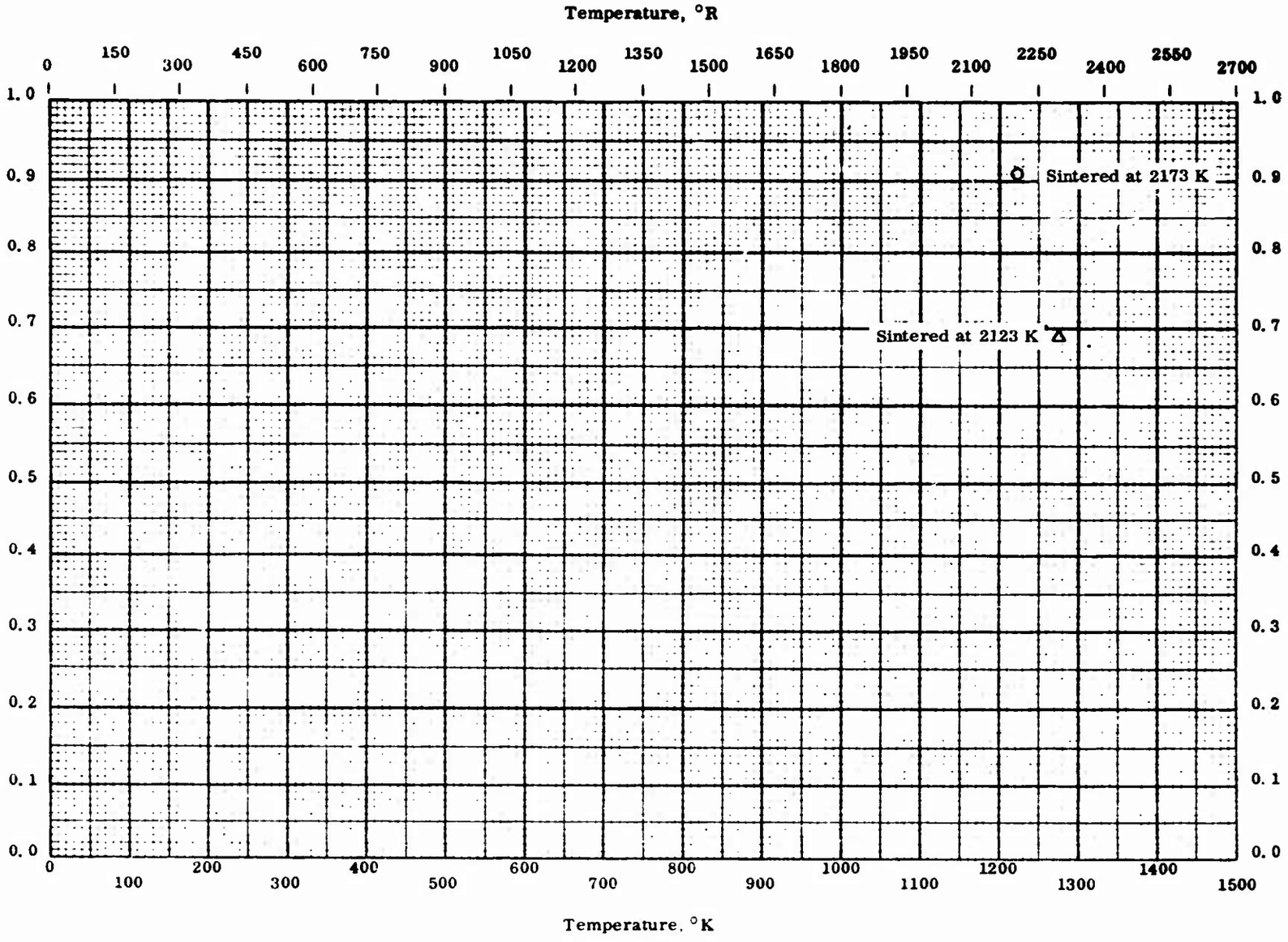


THERMAL LINEAR EXPANSION -- CHROMIUM SESQUIOXIDE

THERMAL LINEAR EXPANSION -- CHROMIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	60-36	299-1273		Pure Cr_2O_3.	Prepared by ball-milling Cr_2O_3 for 4 hrs, passed through a 4 mesh standard screen, mixed with 15% binder (40 g Carbowax 20 M, 20 cc of 2% Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 700 psi into 1 in. disks about 1/4 in. thick, fired to 1500 C for 17 hrs, cooled to room temperature in less than 30 min, and crushed to -325 mesh; measured along a-axis by x-ray diffraction.
◇	60-36	299-1273		Pure Cr_2O_3.	Same as above except measured along c-axis.
△	60-35	298-1773		Cr_2O_3.	
○	46-5	293-1473		Cr_2O_3; density 326 lb ft^{-3}.	



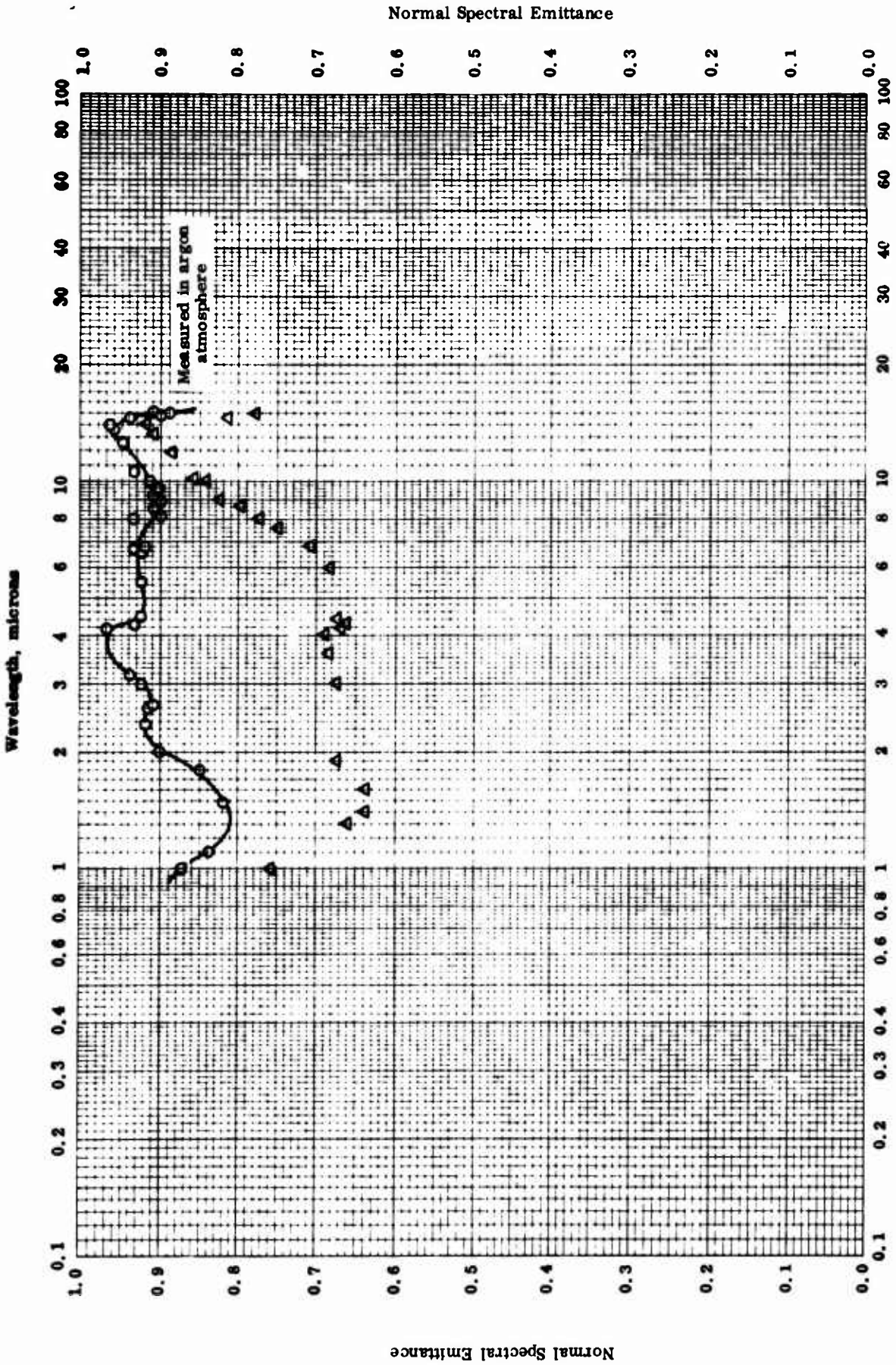
NORMAL TOTAL EMITTANCE -- CHROMIUM SESQUIOXIDE

TPRC

NORMAL TOTAL EMITTANCE -- CHROMIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	63-26	1223	±8	Cr_2O_3, 0.047 in. thickness plate; density 3.15 g cm^{-3}.	Sintered at 2173 K for 2 hrs; measured in argon atmosphere; computed from spectral data.
△	62-23	1273		Cr_2O_3, 99.5 pure; plate 0.051 in. thickness.	Sintered at 2123 K for 2 hrs.

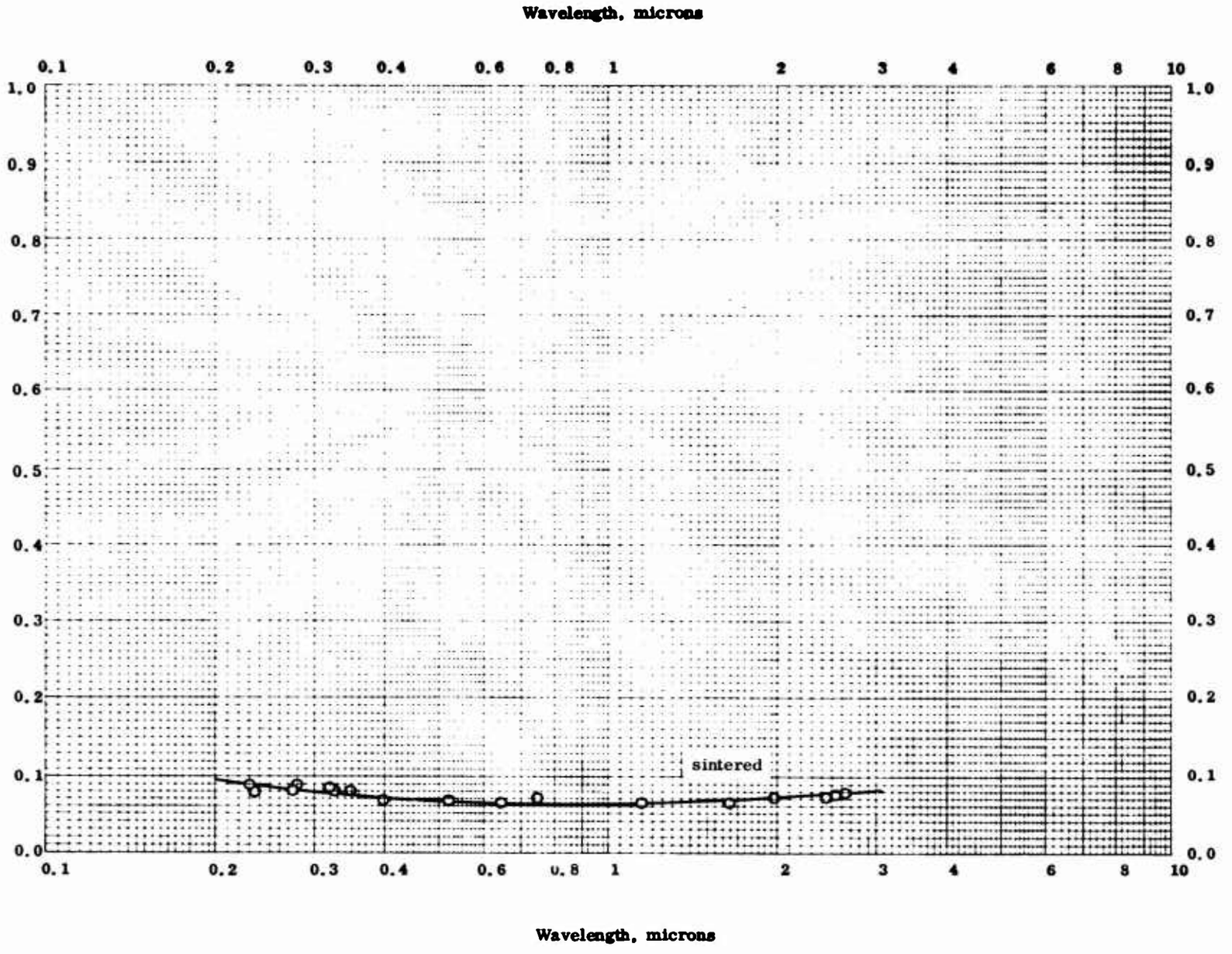


NORMAL SPECTRAL EMITTANCE -- CHROMIUM SESQUIOXIDE

NORMAL SPECTRAL EMITTANCE -- CHROMIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	63-26	1223	1-15		Cr_2O_3, 0.047 in. thickness plate, density 3.15 g cm^{-3}.	Sintered at 2173 K for 2 hrs; measured in argon atmosphere; data taken from a curve.
△	62-23	1273	1-15	< 8.9	Cr_2O_3, 99.5 pure; 0.051 in. thickness.	Sintered at 2123 K for 2 hrs.

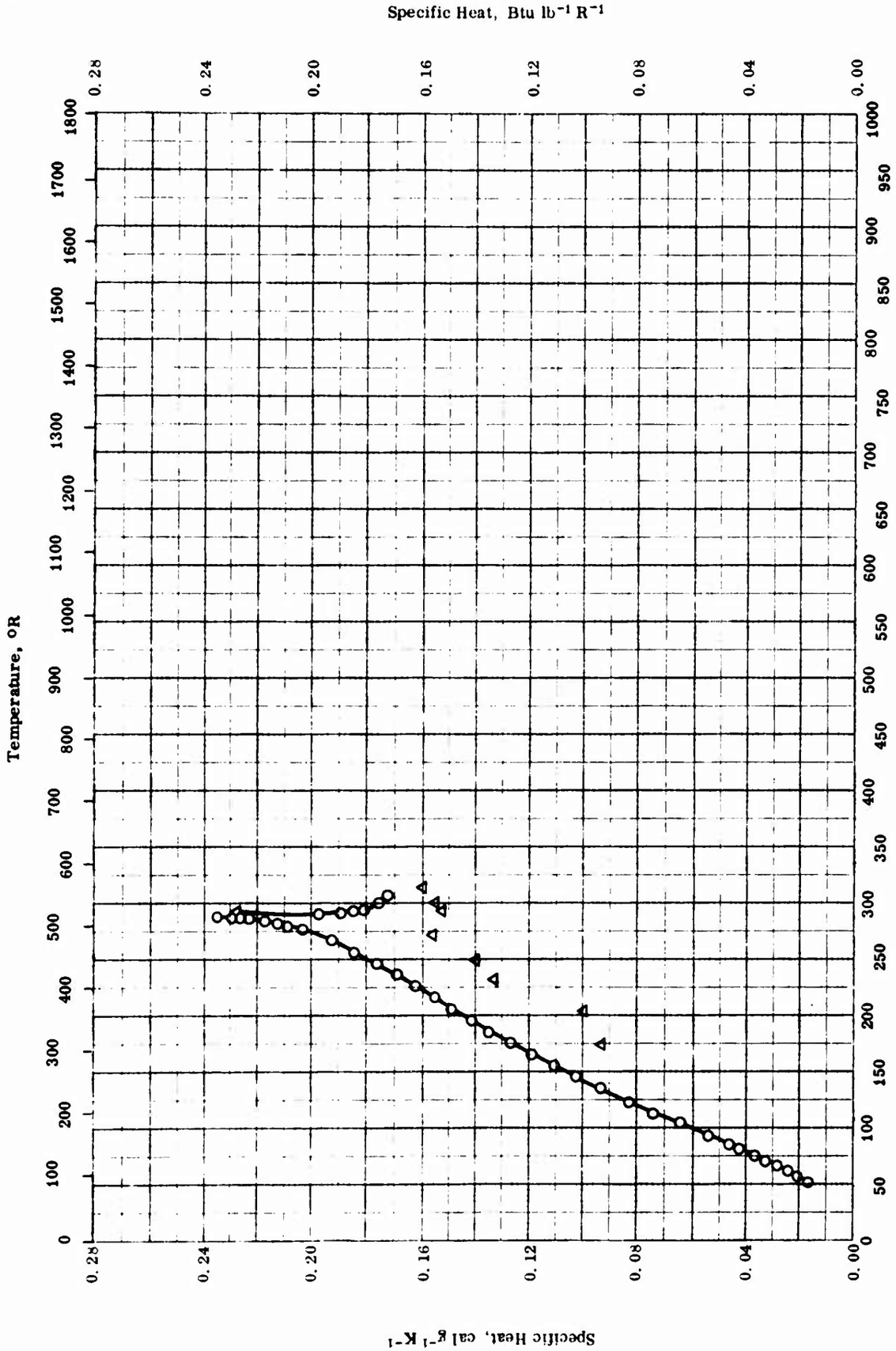


NORMAL SPECTRAL REFLECTANCE -- CHROMIUM SESQUIOXIDE

NORMAL SPECTRAL REFLECTANCE -- CHROMIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
O	63-26	298	0.23-2.65	5	Cr_2O_3, pure, plate 0.047 in. thickness; density 3.15 g cm^{-3}.	Sintered at 2173 K for 2 hrs; data taken from a curve; normal incidence, hemispherical viewing; MgO as reference standard.

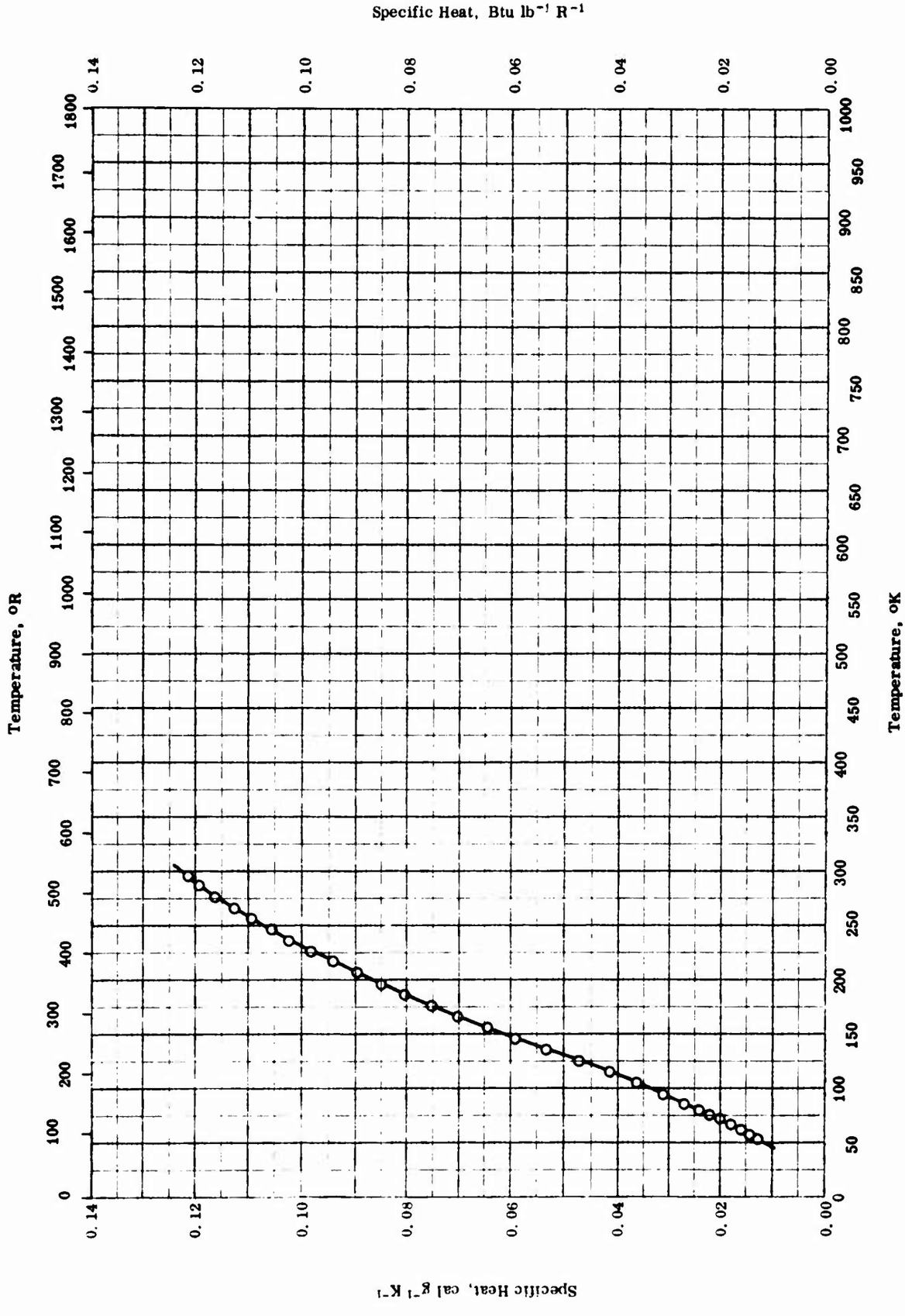


SPECIFIC HEAT -- COBALT (OUS) OXIDE

SPECIFIC HEAT -- COBALT (OUS) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-12	54-308		CoO; 78.61 Co.	Prepared from recrystallized reagent grade cobaltous sulfate heptahydrate.
Δ	54-15	180-325		CoO.	



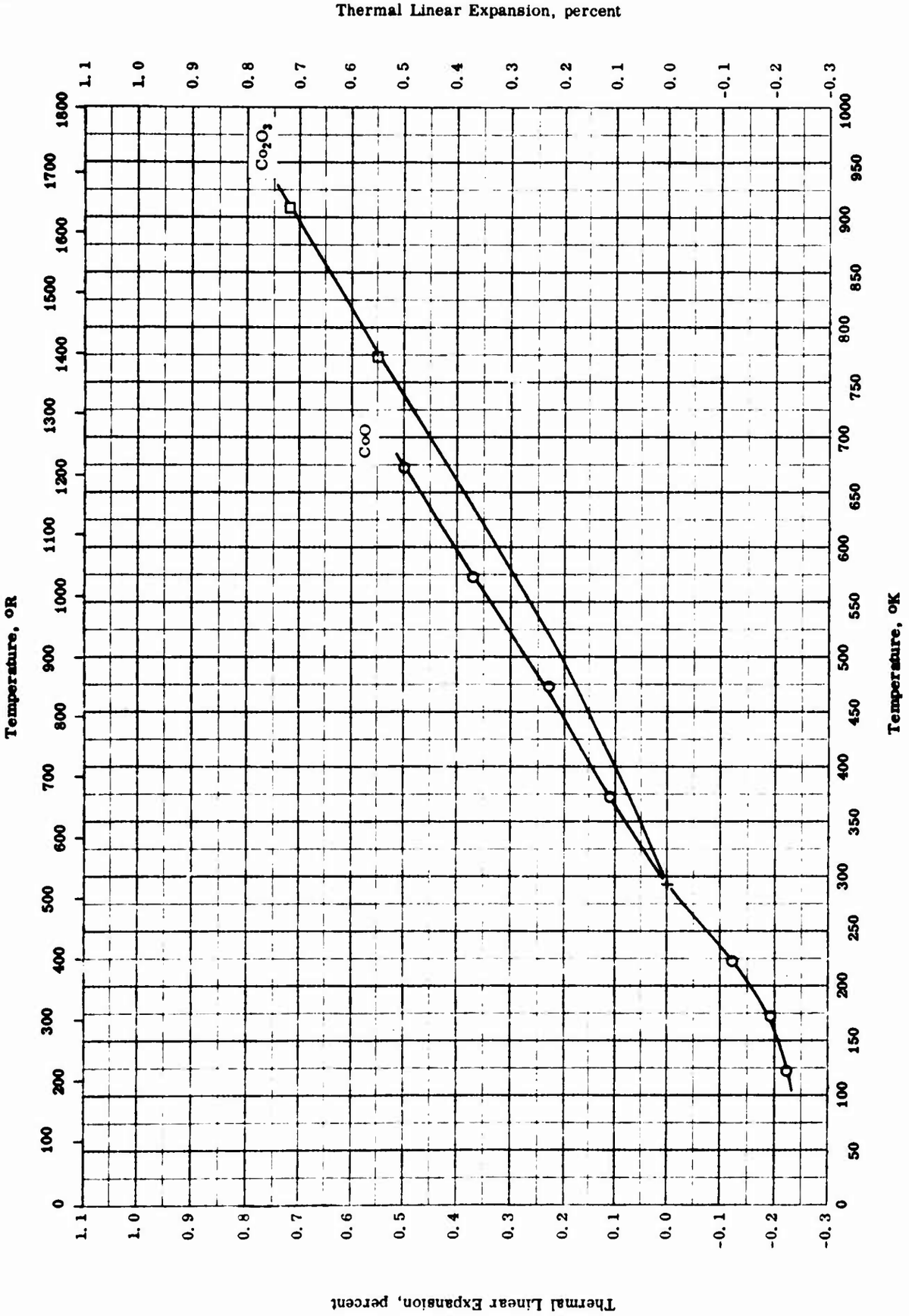
SPECIFIC HEAT -- COBALT (OUS, IC) OXIDE

SPECIFIC HEAT -- COBALT (OUS, IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-12	54-298		Co_3O_4; cobalt spinel.	Prepared from recrystallized reagent grade cobalt sulfate heptahydrate.

TPRC



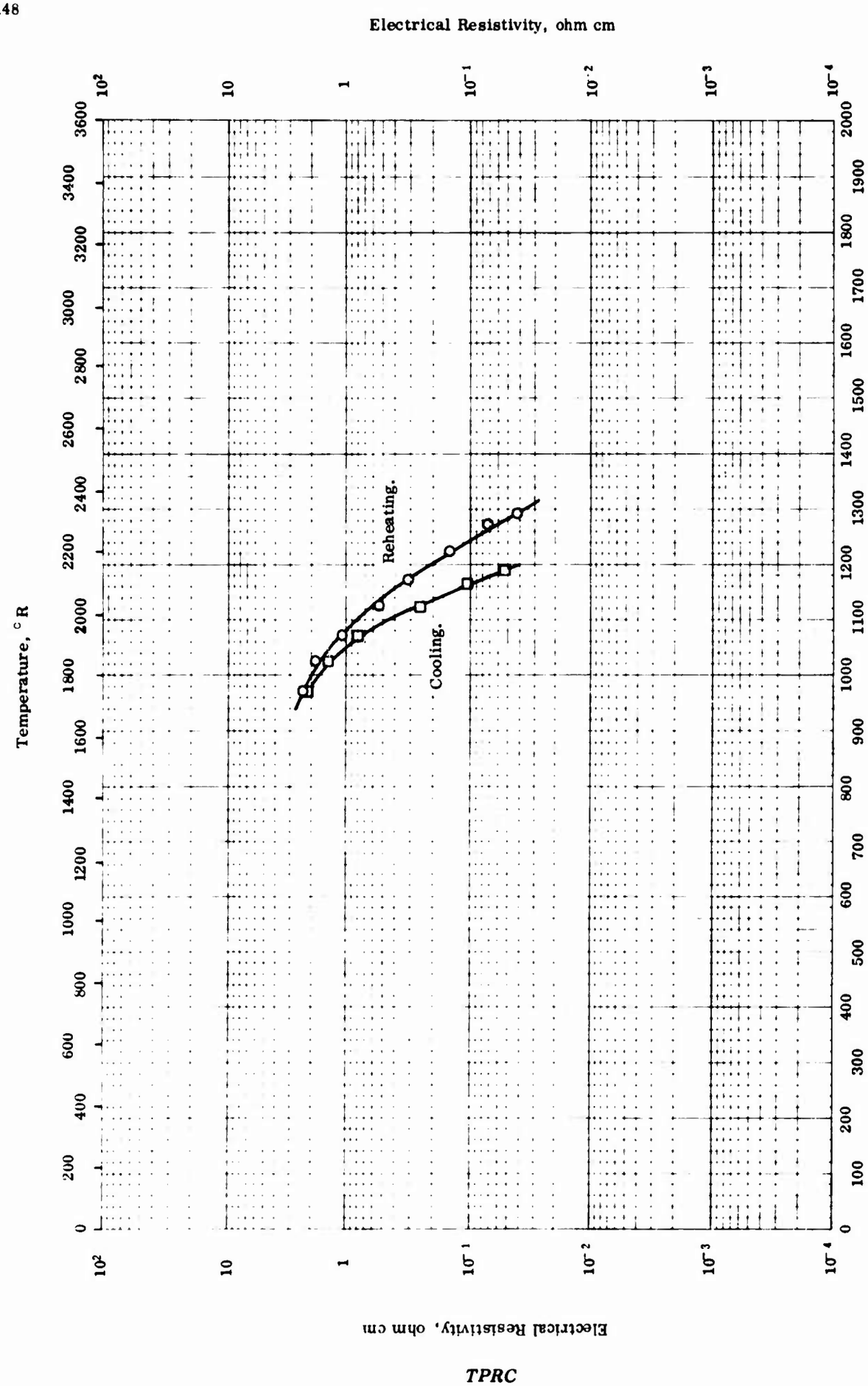
THERMAL LINEAR EXPANSION -- COBALT OXIDES

Thermal Linear Expansion, percent

THERMAL LINEAR EXPANSION -- COBALT OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	48-9	123-673		CoO.	Measured in N_2 atm.
□	60-35	298-908		Co_2O_3.	

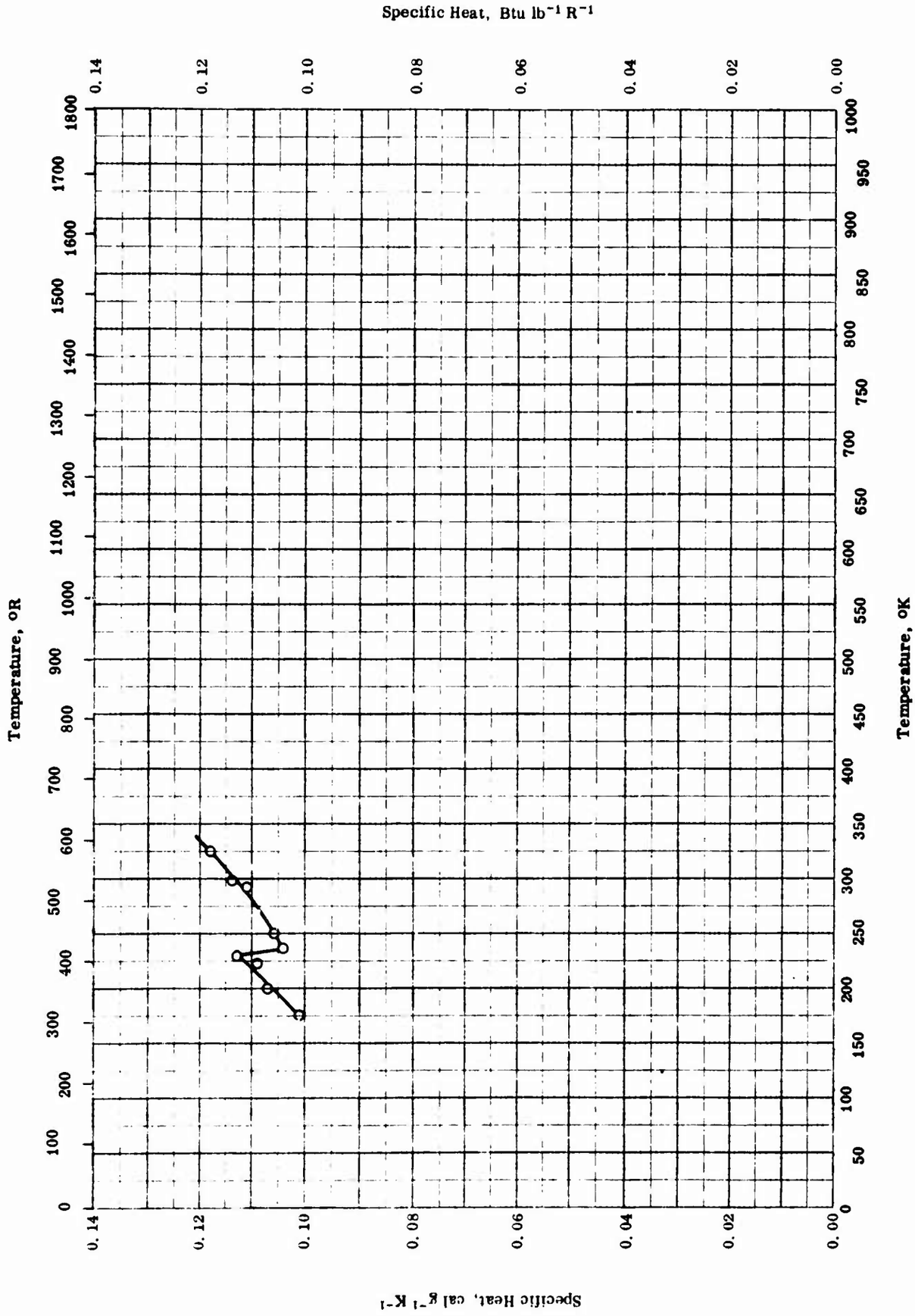


ELECTRICAL RESISTIVITY -- COPPER (IC) OXIDE

ELECTRICAL RESISTIVITY -- COPPER (IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	57-15	973-1273		CuO; Russian brand Ch. D. A.	Reheating.
□	57-15	973-1273		Same as above.	Cooling.

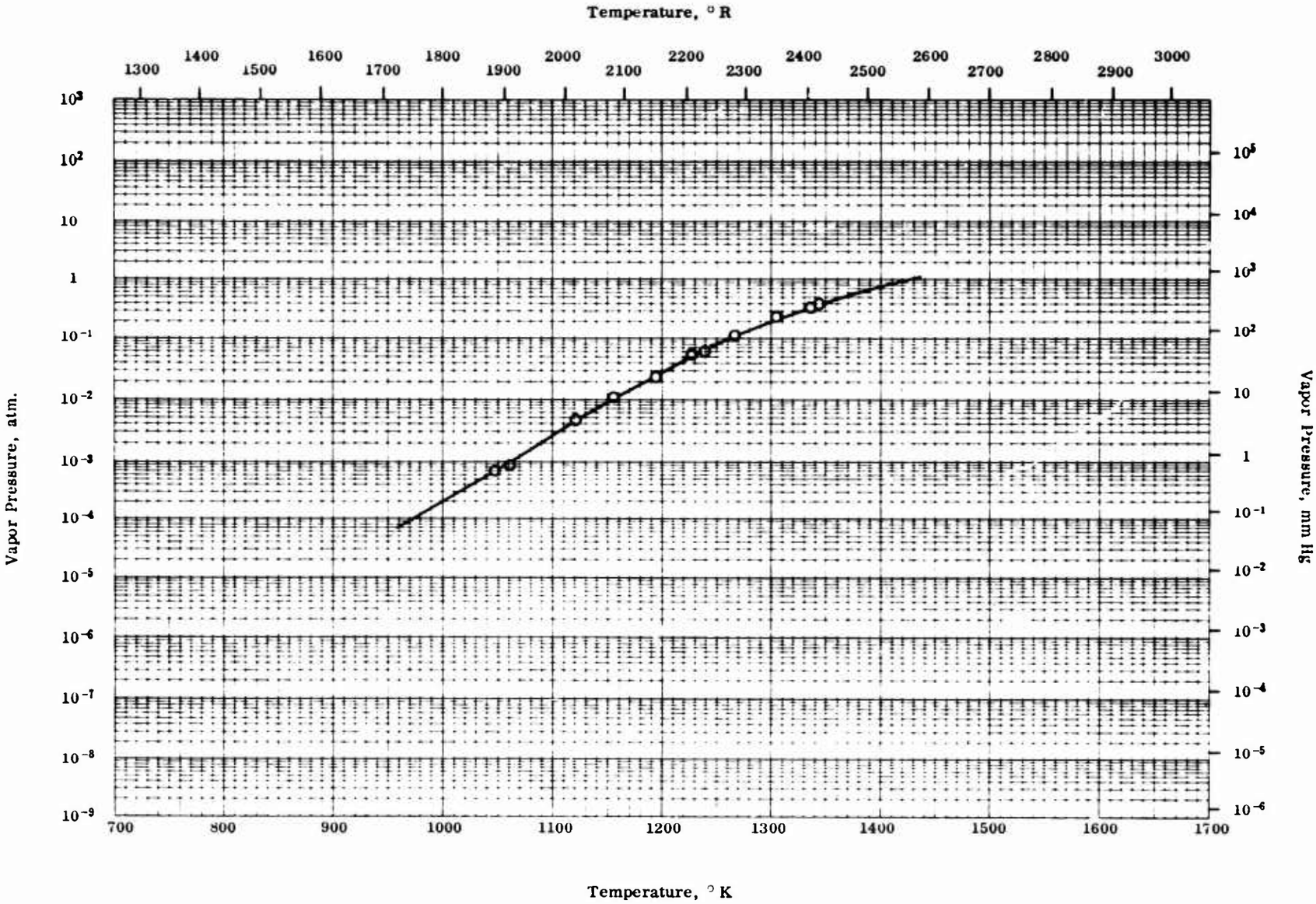


SPECIFIC HEAT -- COPPER (IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-15	175-325		CuO.	

TPRC



VAPOR PRESSURE -- COPPER (IC) OXIDE

TPRC

VAPOR PRESSURE -- COPPER (IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	55-14	1047-1342		CuO.	

PROPERTIES OF DYSPROSIUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density	8.556*	535
Melting Point	2613	4704

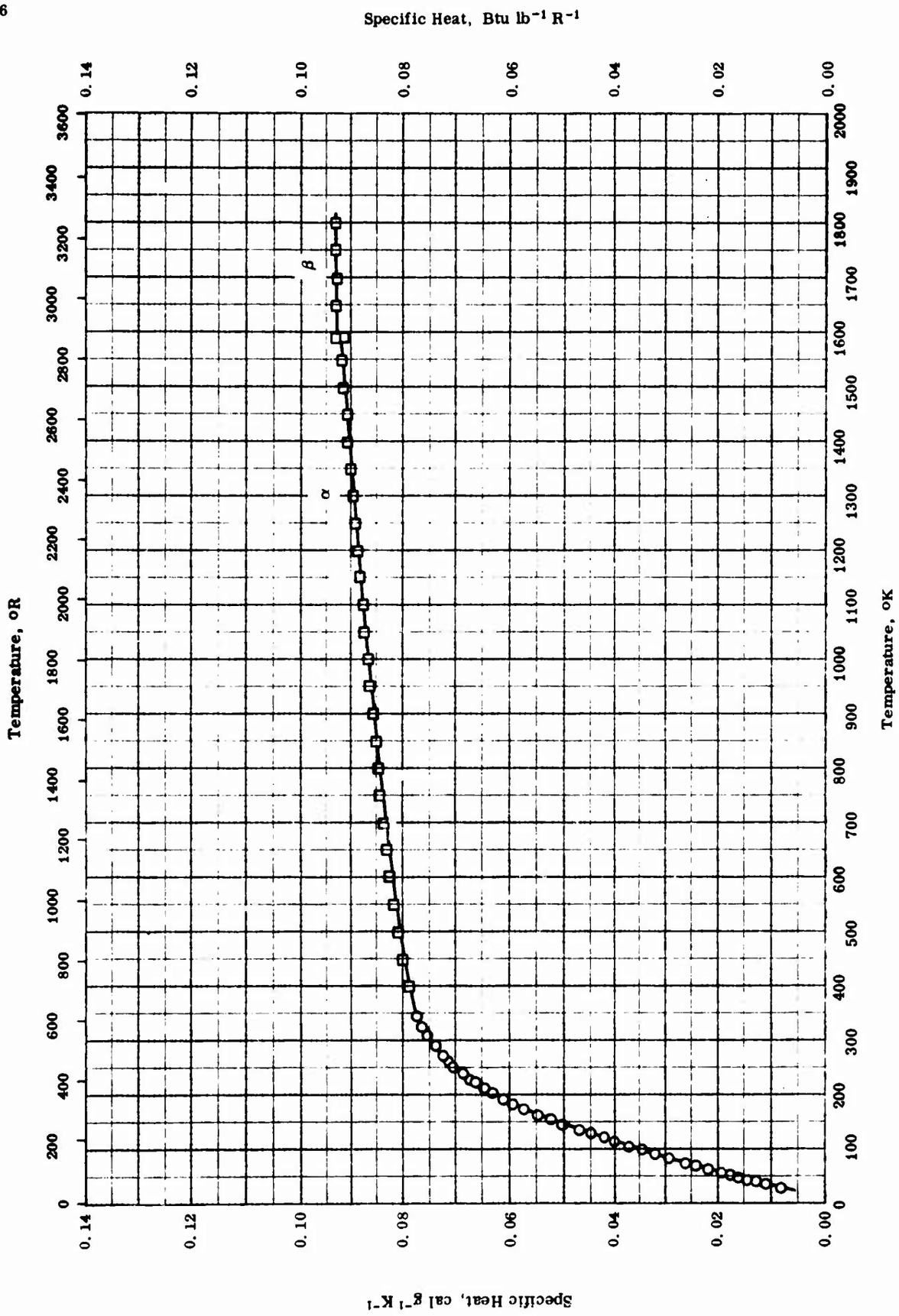
*Handbook of Chemistry and Physics. (Ref. 64-16)

REPORTED VALUES

Melting Point	K	R
○	2613 ± 10	4704 ± 18
□	2613	4704
△	2613 ± 10	4704 ± 18

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	56-22	2603-2623		Dy_2O_3	M. P. by observing the first liquid drop on V-shaped ribbon.
□	64-9	2613		Dy_2O_3.	
△	60-26	2603-2623		Dy_2O_3.	

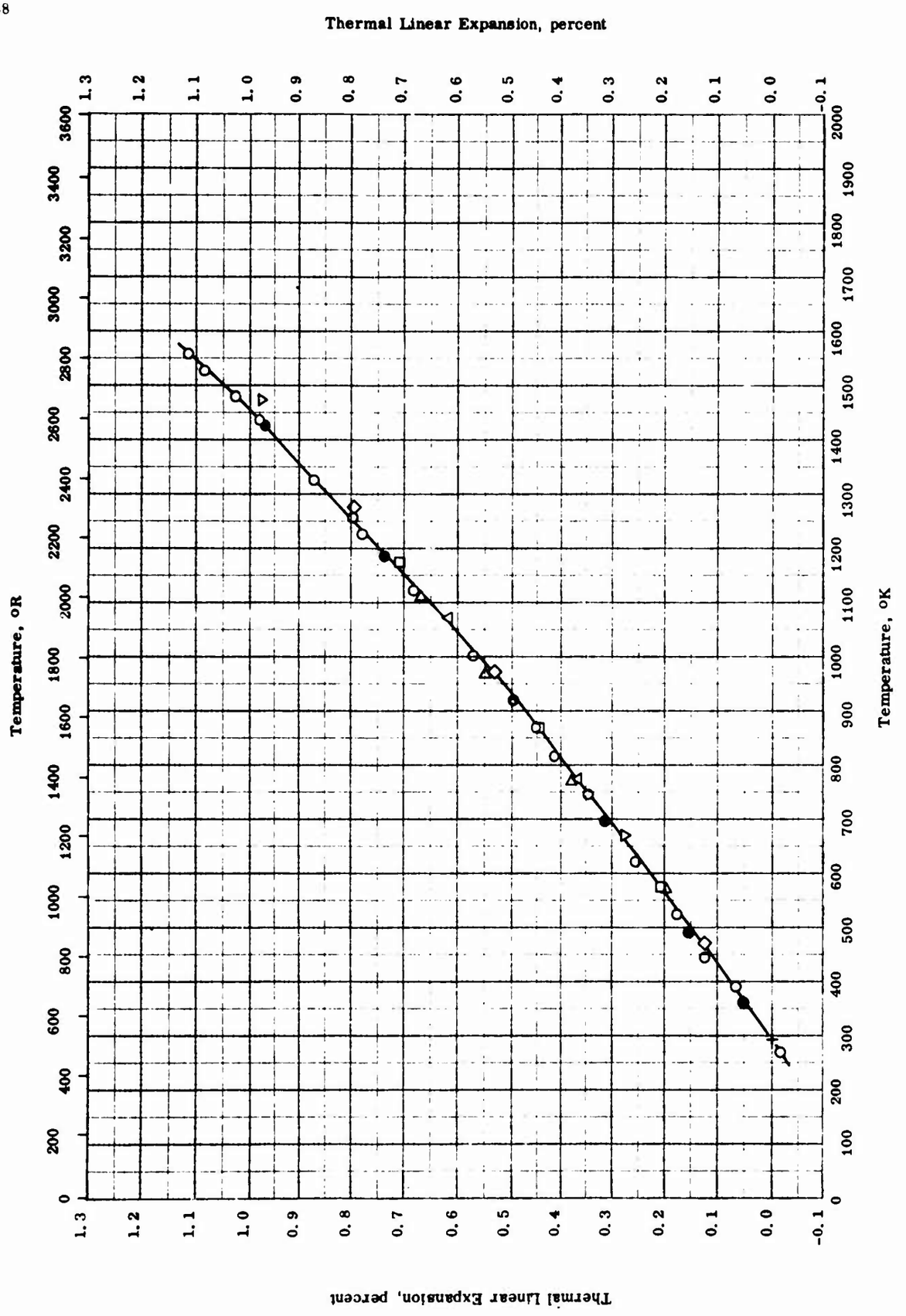


SPECIFIC HEAT -- DYSPROSIUM OXIDE

SPECIFIC HEAT -- DYSPROSIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-13 also 63-19	6-346	0.1	Dy_2O_3; 99.9 Dy_2O_3, 0.0150 Y, 0.010 C, 0.010 Si.	Powder specimen; under helium atm.
□	63-15	400-1800		99.9 Dy_2O_3.	Dried at 1100 - 1200 C.



THERMAL LINEAR EXPANSION -- DYSPROSIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-41	273-1558	1.1-6.0	Dy_2O_3 from Michigan Chemical Co., St. Louis, Mich.; cubic, rare-earth oxide type C; 99.0 Dy_2O_3 in regard to total rare-earth content; 0.3 - 3.0 Y, 0.01 - 0.1 Ca, 0.001 - 0.01 Mg, and 0.0003 - 0.003 Si.	Sintered at 1150 C for 24 hrs, packed into alumina sample holder, resintered at 1150 C, cooled to 350 C, and placed in vacuum desiccator for storage; x-ray diffractometer method.
●	61-41	366-1558	1.1-6.0	Same as above.	Cooling cycle for above sample.
□	63-35	298-1174		Dy_2O_3; 0.3 - 3.0 Y, 0.01 - 0.1 Si, 0.003 - 0.03 Ca, and 0.0003 - 0.003 Mg; bulk density after expansion run by mercury displacement at low pressure 7.2 g cm^{-3}.	Powder calcined at 1200 C for approx. 1 hr, mixed with binder (2% varsol plus 2% paraffin dissolved in benzene), dry pressed at 25,000 psi, sintered at 1500 C for 1 hr, ground into shape, heated to 1000 C for 1 hr, reground, heated to 1400 C for 3 hrs, and desiccated; measured with heating rate of approx. 5 C min^{-1}.
◇	63-35	298-1275		Same as above.	Second run for above sample.
△	63-35	298-1271		Same as above.	Third run for above sample.
▽	61-44	298-1473		>99 pure Dy_2O_3 from Research Chemical, Inc., Burbank, Calif.	X-ray method.
▷	57-37	293-1113		Dysprosia, Dy_2O_3.	Hot pressed at 1800 C in graphite mold to 95% of theoretical density.

PROPERTIES OF ERBIUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density	8.65	540

REPORTED VALUES

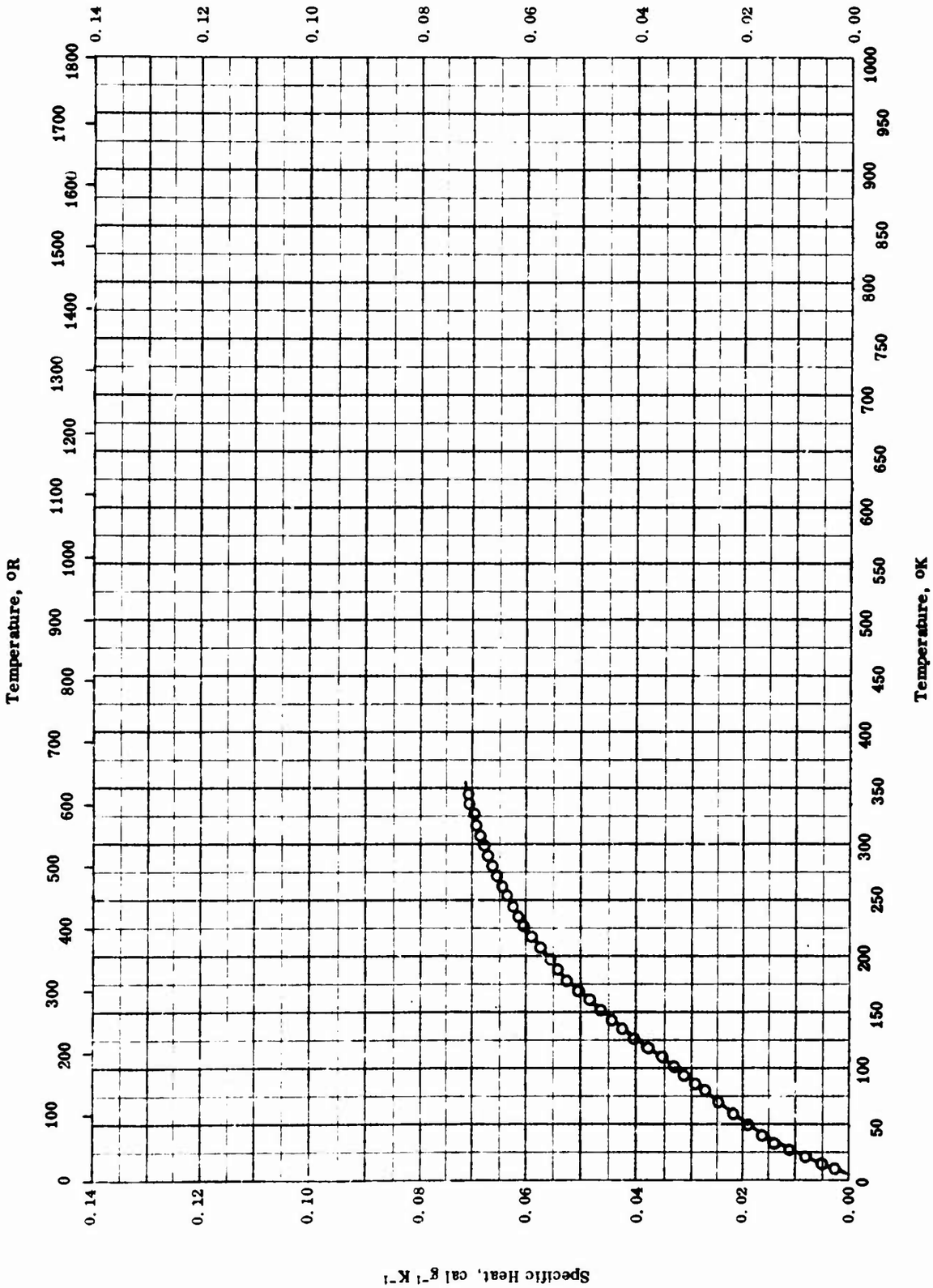
Density	g cm^{-3}	lb ft^{-3}
O	8.65	539.8

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PROPERTIES OF ERBIUM OXIDE

REFERENCE INFORMATION

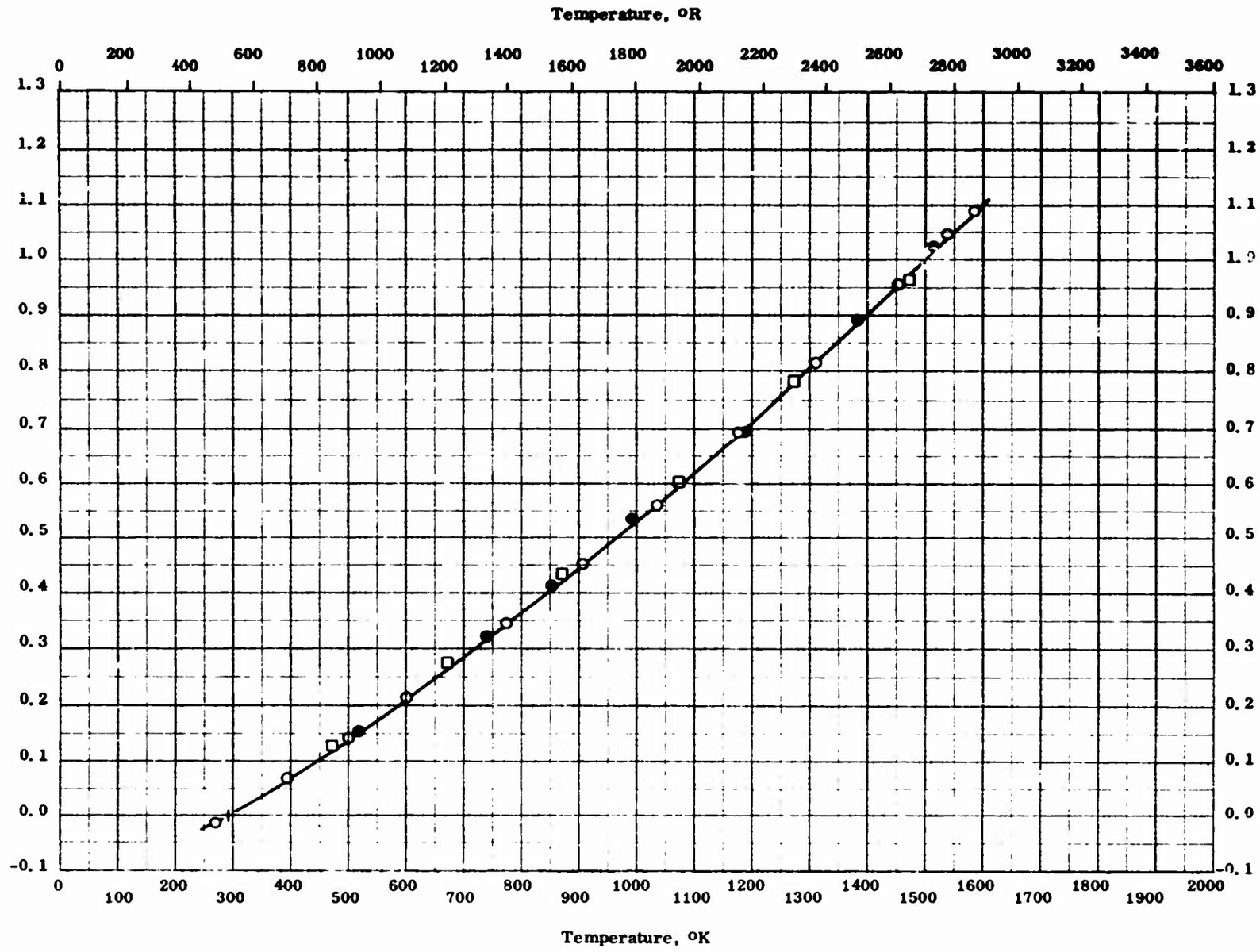
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	62-16	298		Er_2O_3.	



SPECIFIC HEAT -- ERBIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Repr. Error %	Sample Specifications	Remarks
O	61-13 also 63-19	5-346	0.1	99.9 Er_2O_3, 0.0350 Tm, 0.010 Ca, 0.010 Dy, 0.010 Si, and 0.003 Ho.	Powder specimen; helium atm.

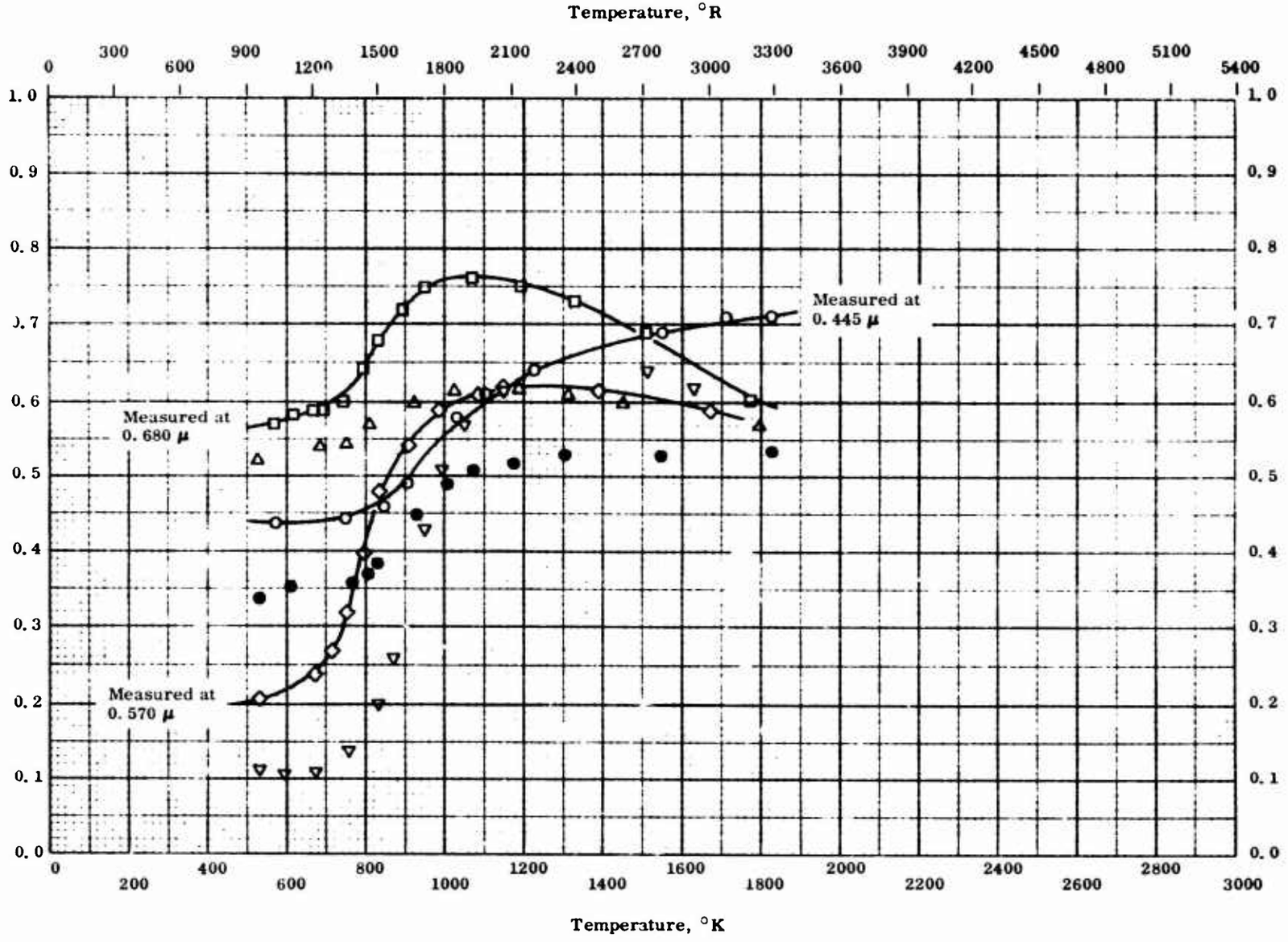


THERMAL LINEAR EXPANSION -- ERBIUM OXIDE

THERMAL LINEAR EXPANSION -- ERBIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specification.	Remarks
○	61-41	273-1585	1.1-6.0	Code 1305 Er_2O_3 from Lindsay Chemical Co., West Chicago, Ill.; 99.9 Er_2O_3 in regard to total rare-earth content; 0.003 - 0.03 Ca, 0.0003 - 0.003 Si, and trace of Mg; cubic, rare-earth oxide type C.	Sintered at 1300 C for 24 hrs, packed into alumina sample holder, resintered at 1350 C for 12 hrs, cooled to 300 C, and placed in vacuum desiccator for storage; measured with x-ray diffractometer.
●	61-41	521-1585	1.1-6.0	Same as above.	Cooling cycle for above sample.
□	61-44	298-1473		>99 Er_2O_3 from Res. Chem. Inc., Burbank, Calif.	X-ray method.



NORMAL SPECTRAL EMITTANCE -- ERBIUM OXIDE

TPRC

NORMAL SPECTRAL EMITTANCE -- ERBIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Wavelength μ	Temp. Range °K	Rept. Error%	Sample Specifications	Remarks
○	63-25	0.445	578-1833		Er_2O_3.	Powdered material compressed to 75000 psi fired at 1773 K for 24 hrs; ground to 0.125 in. thickness; measured in air; calculated from reflectance data; data taken from smooth curve.
●	63-25	0.488	528-1823		Same as above.	Same as above.
△	63-25	0.533	523-1793		Same as above.	Same as above.
◇	63-25	0.570	533-1673		Same as above.	Same as above.
▽	63-25	0.605	533-1633		Same as above.	Same as above.
□	63-25	0.680	573-1773		Same as above.	Same as above.

PROPERTIES OF EUROPIUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	7.79	486
Melting Point	2323	4182

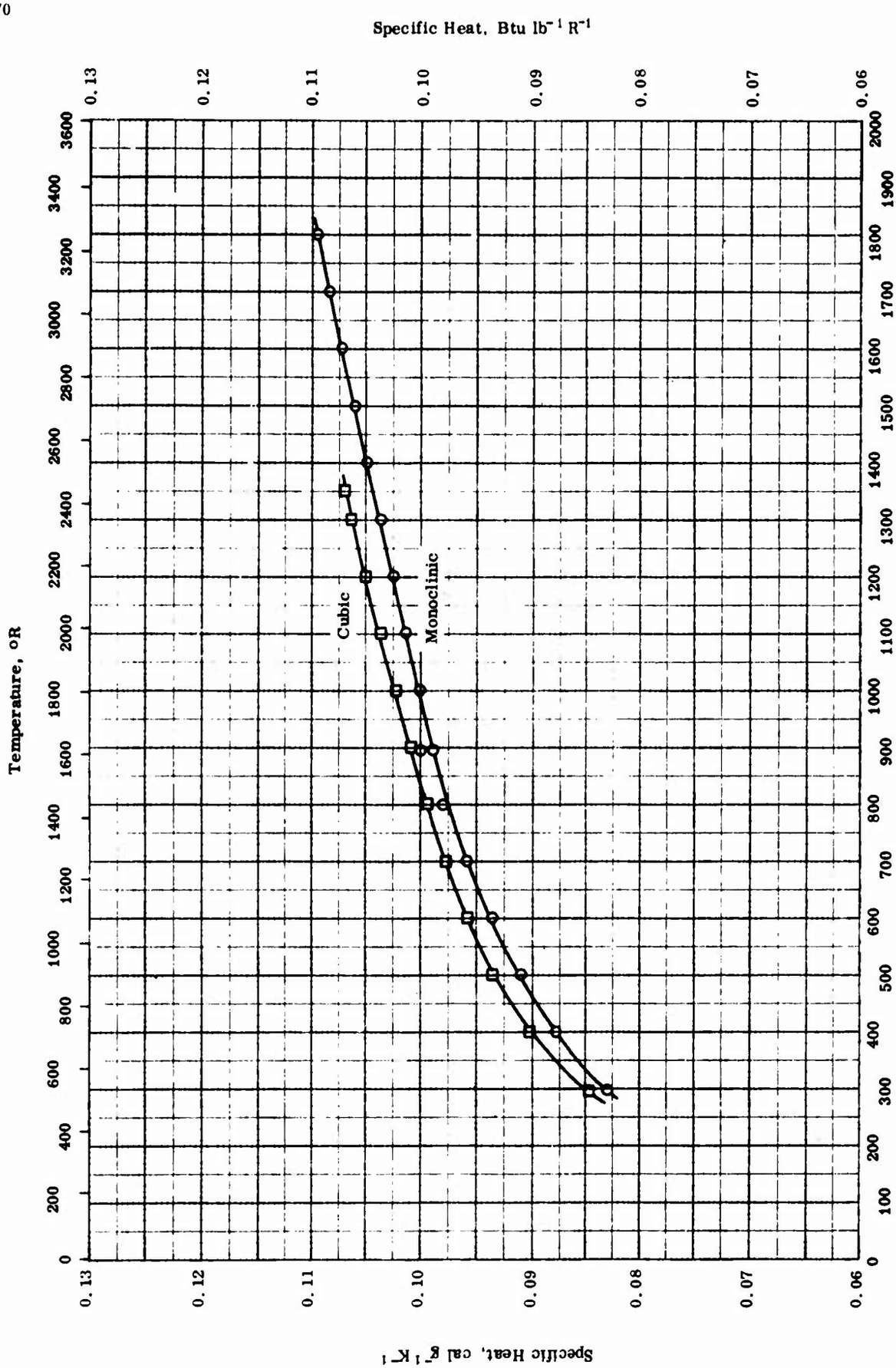
REPORTED VALUES

Density	g cm^{-3}	lb ft^{-3}
□	7.79	486.1
Melting Point	K	R
○	2323 ± 30	4182 ± 54

PROPERTIES OF EUROPIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	56-22	2293-2353		Eu_2O_3.	M. P. by observing the first liquid drop on V-shaped ribbon.
□	62-16	298		Eu_2O_3 - C.	

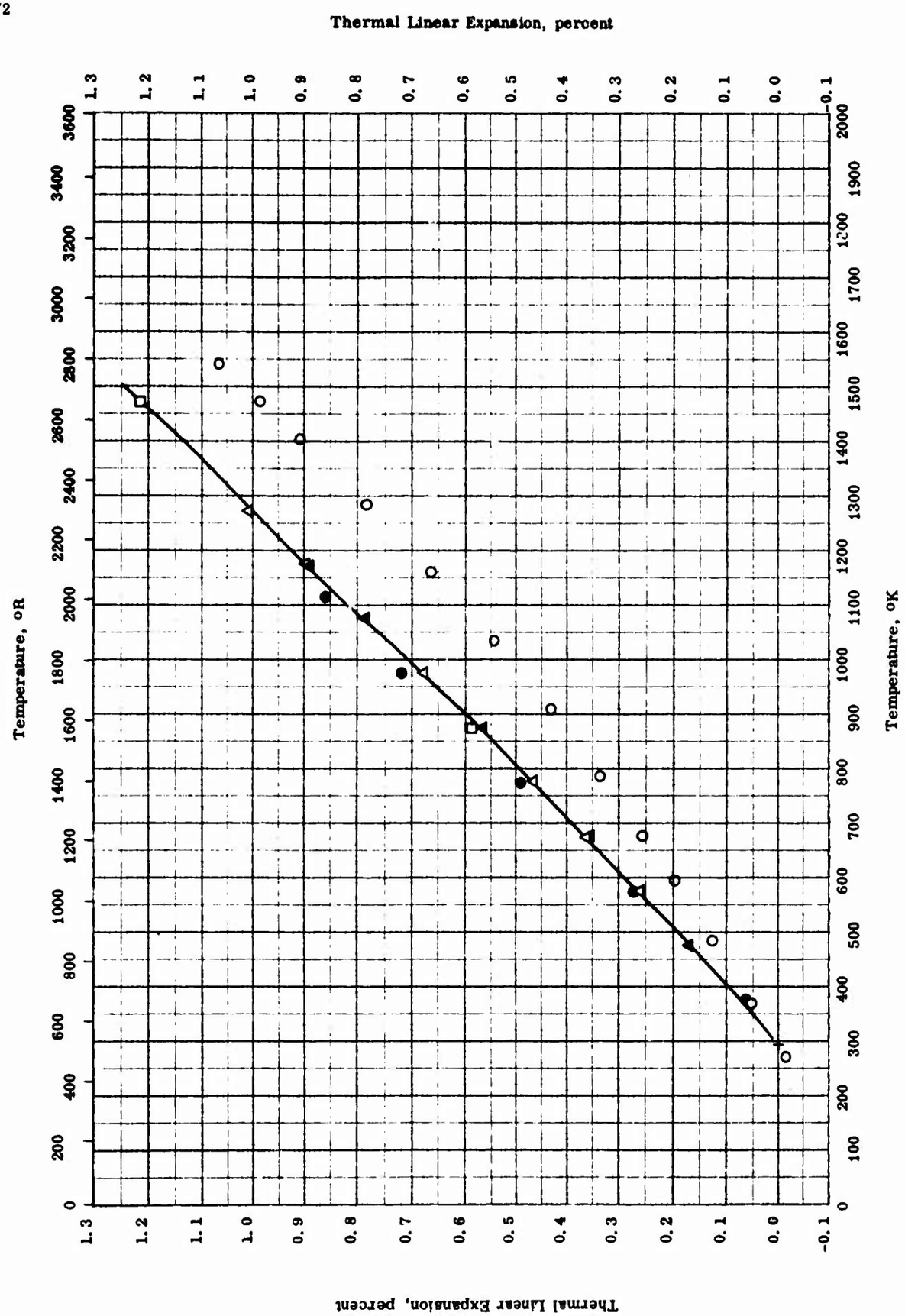


SPECIFIC HEAT -- EUROPIUM OXIDE

SPECIFIC HEAT -- EUROPIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-11	298-1802	0.2	99.9 Eu_2O_3; monoclinic structure.	Under helium atm.
□	62-11	298-1350	0.2	99.9 Eu_2O_3; cubic structure.	Same as above.



THERMAL LINEAR EXPANSION -- EUROPIUM OXIDE

Thermal Linear Expansion, percent

THERMAL LINEAR EXPANSION -- EUROPIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-41	273-1540	1.1-6.0	Code 1011 Eu_2O_3 from Lindsay Chemical Co., West Chicago, Ill.; 99.9 Eu_2O_3 in regard to total rare-earth content; 0.03 - 0.3 La, 0.003 - 0.03 Ca, Pb, Si, 0.001 - 0.01 Fe, and 0.0003 - 0.003 Mg; cubic, rare-earth oxide type C.	Sintered at 1000 C for 16 hrs, packed into alumina sample holder, resintered at 1060 C for 12 hrs, cooled to 300 C, and placed in a vacuum desiccator for storage; x-ray diffractometer method.
△	63-35	298-1270		Eu_2O_3; 0.03 - 0.3 Sm, 0.003 - 0.03 Ca, 0.001 - 0.01 Al, Si, and 0.0003 - 0.003 Fe, Mg, Y; monoclinic; bulk density after expansion run by mercury displacement at low pressure 6.5 g cm^{-3}.	Calcined at 1200 C for approx. 1 hr, mixed with binder (2% varsol plus 2% paraffin dissolved in benzene), hot pressed at approx. 2600 psi to 1400 C, ground into shape, matured at 1500 C for approx. 1 hr, reground, heated to 1500 C for 1 hr, and desiccated; measured with heating rate of approx. 5 C min^{-1}.
▲	63-35	298-1271		Same as above.	Second run for above sample.
□	59-20	273-1473		Eu_2O_3.	Mixture of 21 powder (calcined at 900 C for 10 - 12 hrs) and 79 powder (precalcined at 1300 C for 3 hrs) dry pressed into a bar without binder or lubricant at 13720 psi, fired at 1500 C for 2 hrs, and machined into a rod; measured with heating rate of 3 C min^{-1}.
●	57-37	293-1113		Eu_2O_3; europia.	Hot pressed at 1800 C in graphite mold to 95% of theoretical density.

PROPERTIES OF GADOLINIUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	7.64	477
Melting Point	2623	4721

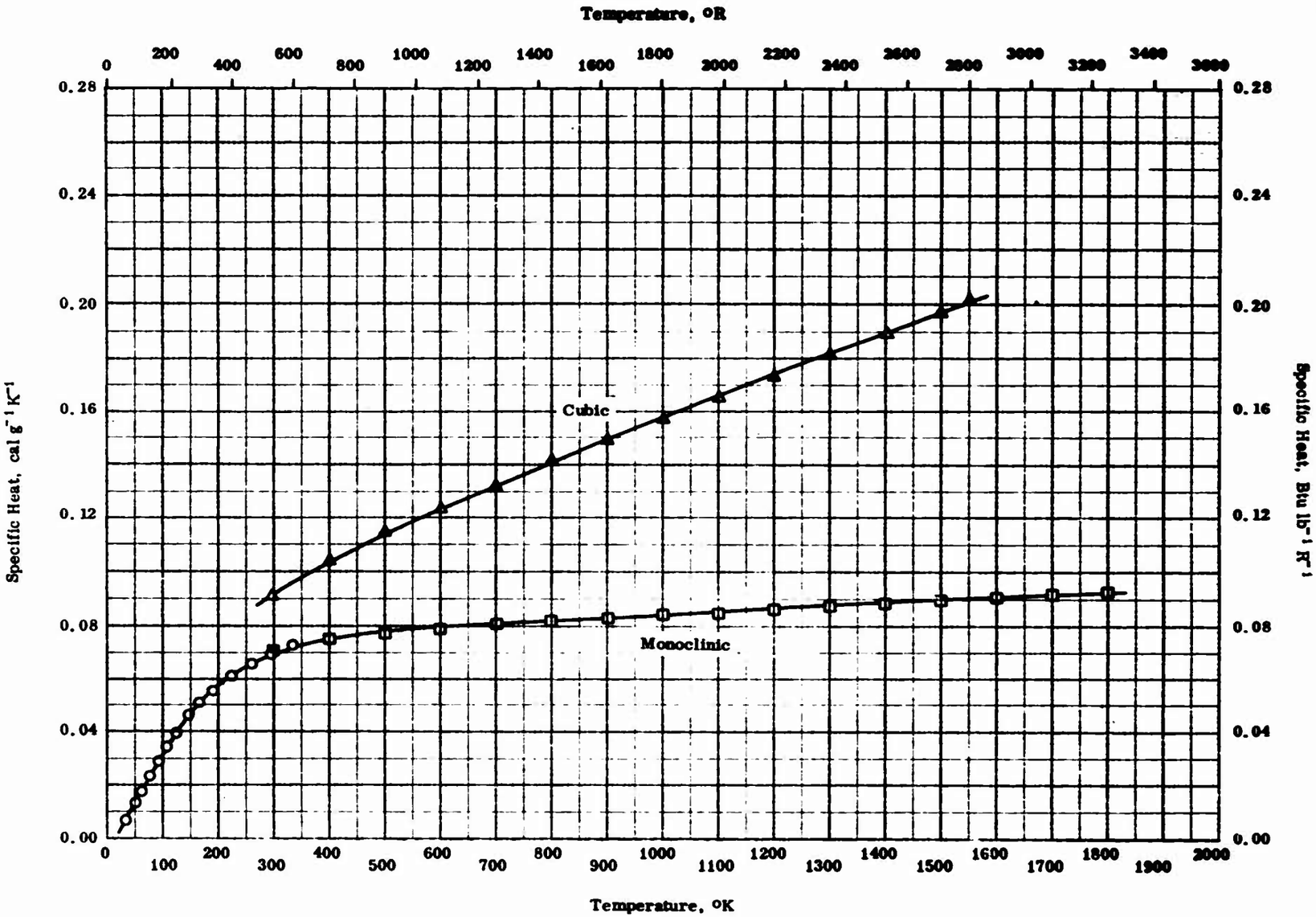
REPORTED VALUES

		$g\ cm^{-3}$	$lb\ ft^{-3}$
Density	⊐	6.97	435
	△	7.64	477
	▽	8.22	512.9
	◁	7.40	461.8
		K	**R**
Melting Point	○	2623 ± 50	4721 ± 90
	◇	2603 ± 20	4686 ± 36

PROPERTIES OF GADOLINIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	57-8	2573-2673		2 Tb, 0.5 each Ce, Ho, Nd, Sm, Eu, and Dy, 0.2 Y, and 0.05 > each Lu, La, Er, and Yb.	M.P. by observing first liquid drop.
□	57-8	298		Same as above.	Pressed at 2700 psi and fired 2 hrs at 1300 C; density by weight and volume by water displacement.
△	57-8	298		Same as above.	Same as above; sintered and cracked.
◇	56-22	2583 2623		Gd_2O_3.	M.P. by observing first liquid drop from V-shaped ribbon.
▽	62-16	298		Gd_2O_3 - B.	
◁	62-16	298		Gd_2O_3 - C.	

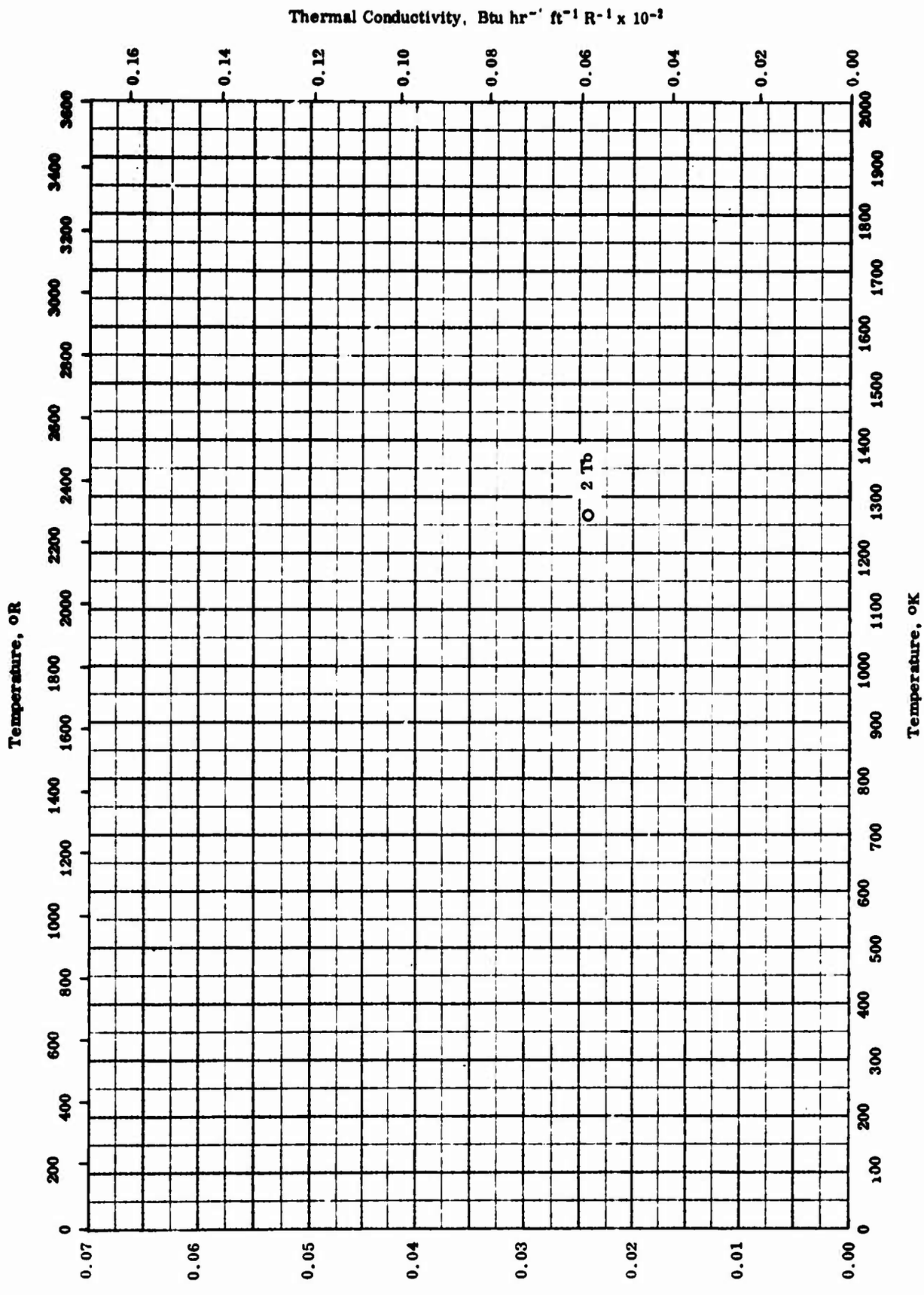


SPECIFIC HEAT -- GADOLINIUM OXIDE

TPRC

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	61-13 also 60-12	7-346		99.90 Gd_2O_3, 0.045 Y, 0.020 Si, 0.010 Ca, and 0.0075 Eu.	Pelleted under 2000-4000 psi and fired at 1170 K; under helium atm.
□	62-11	298-1802	0.2	99.9 Gd_2O_3; monoclinic structure.	Under helium atm.
△	62-11	298-1550	0.2	99.9 Gd_2O_3; cubic structure.	Under helium atm.

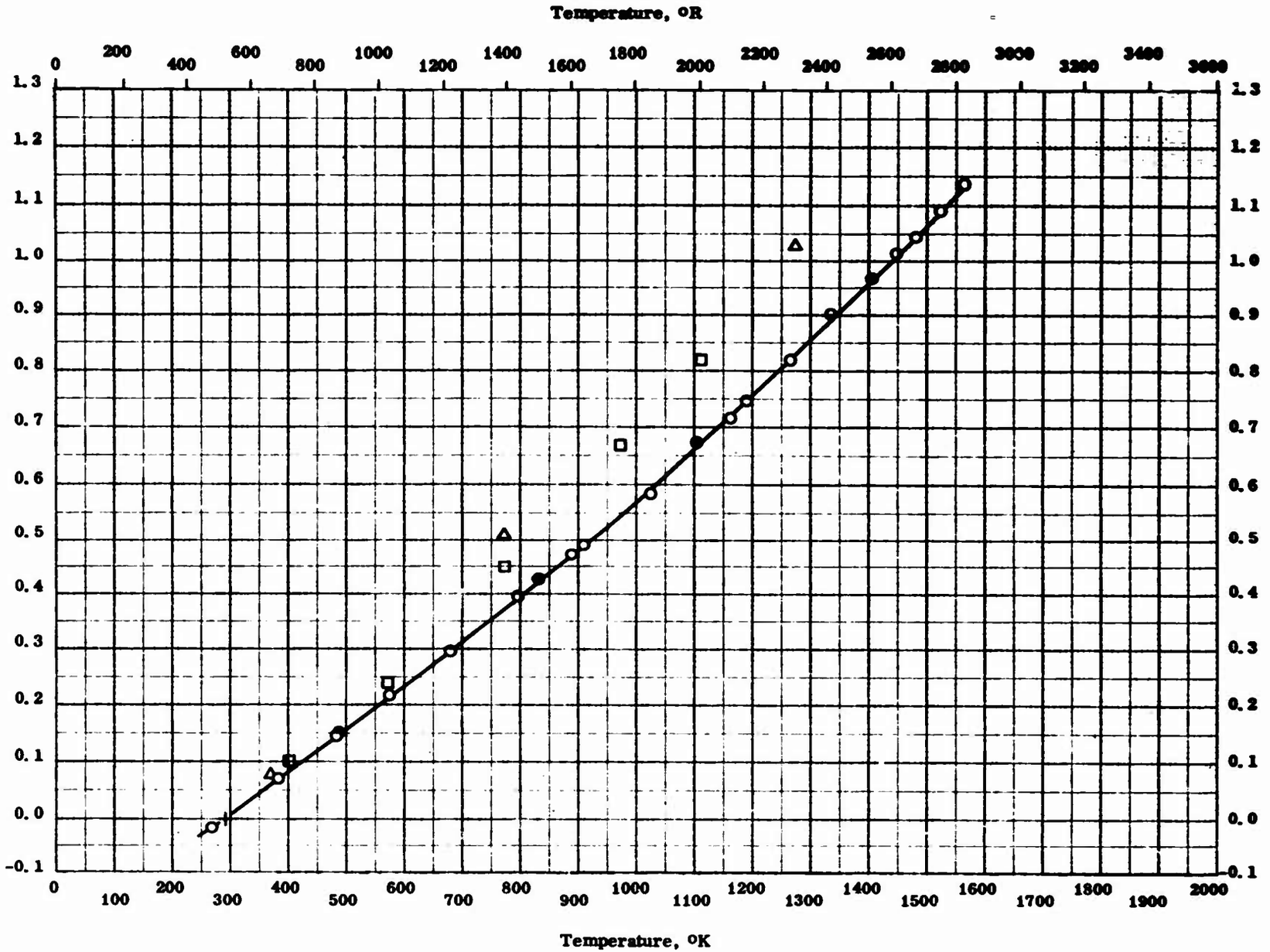


THERMAL CONDUCTIVITY -- GADOLINIUM OXIDE

THERMAL CONDUCTIVITY -- GADOLINIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-8	1270		95.5 Gd_2O_3 and 2 Tb; density 7.64 g cm^{-3} and porosity 1.2%.	Fired at 1500 C.



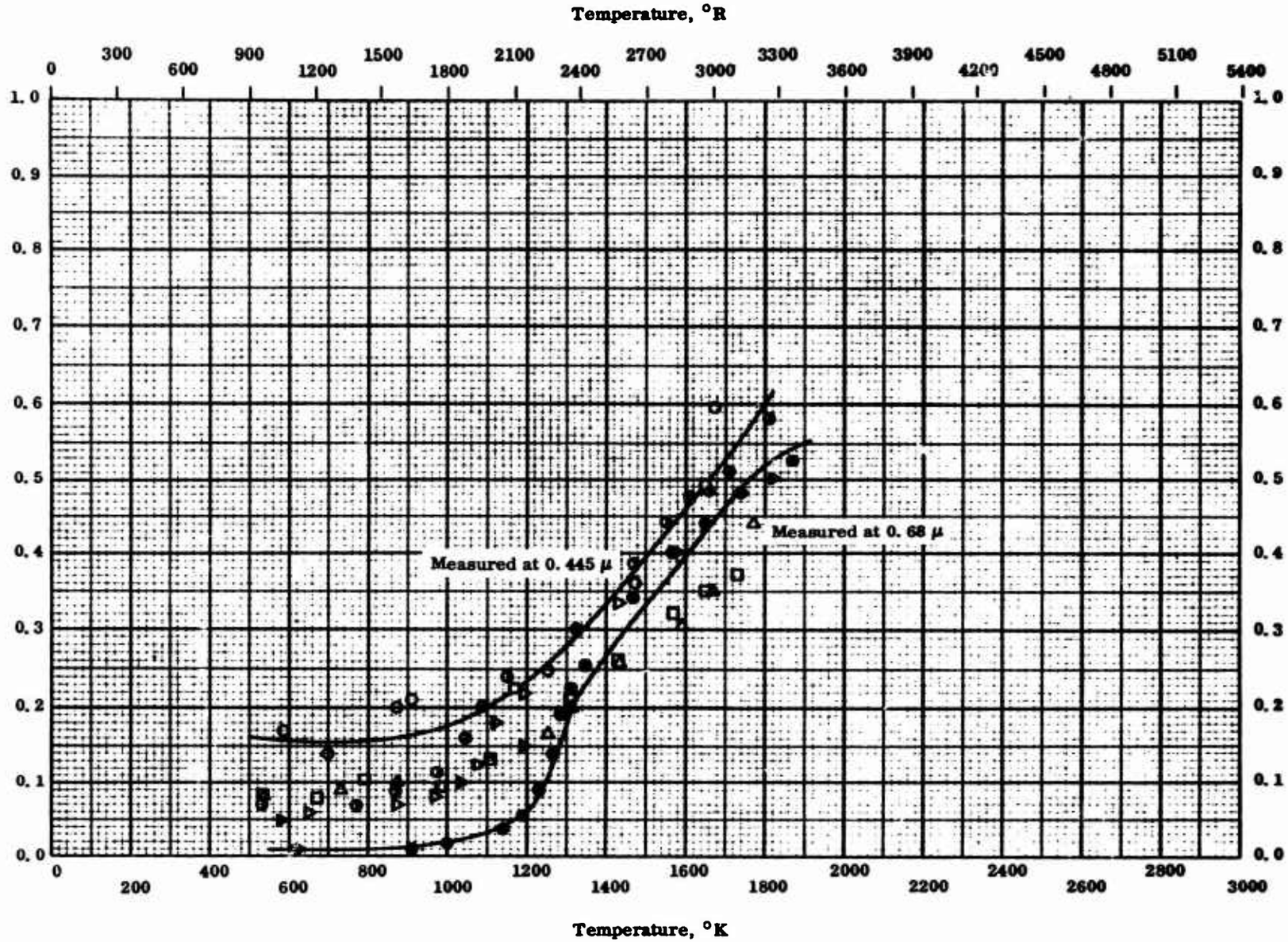
THERMAL LINEAR EXPANSION -- GADOLINIUM OXIDE

TPRC

THERMAL LINEAR EXPANSION -- GADOLINIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-41	273-1568	1.1-6.0	Gd_2O_3 from Michigan Chemical Co., St. Louis, Mich.; 99.9 Gd_2O_3 in regard to total rare-earth content; 0.003 - 0.03 Ca, Y, 0.001 - 0.01 Si, and 0.0003 - 0.003 Fe, Mg; cubic phase.	Sintered at 1150 C for 24 hrs, packed into alumina sample holder, resintered at 1150 C for 12 hrs, cooled to 350 C, and placed in a vacuum for storage; x-ray diffractometer method.
●	61-41	491-1568	1.1-6.0	Same as above.	Cooling cycle for above sample.
△	57-8	293-1273		Gd_2O_3; 2 Tb and 0.5 each of Ce, Nd, Sm, Eu, and Dy.	Pressed into bars at 2700 psi and fired 2 hrs at 1500 C; sintering and cracking were noted.
□	57-37	293-1113		Gd_2O_3.	Hot pressed at 1800 C in graphite mold to 95% theoretical density.



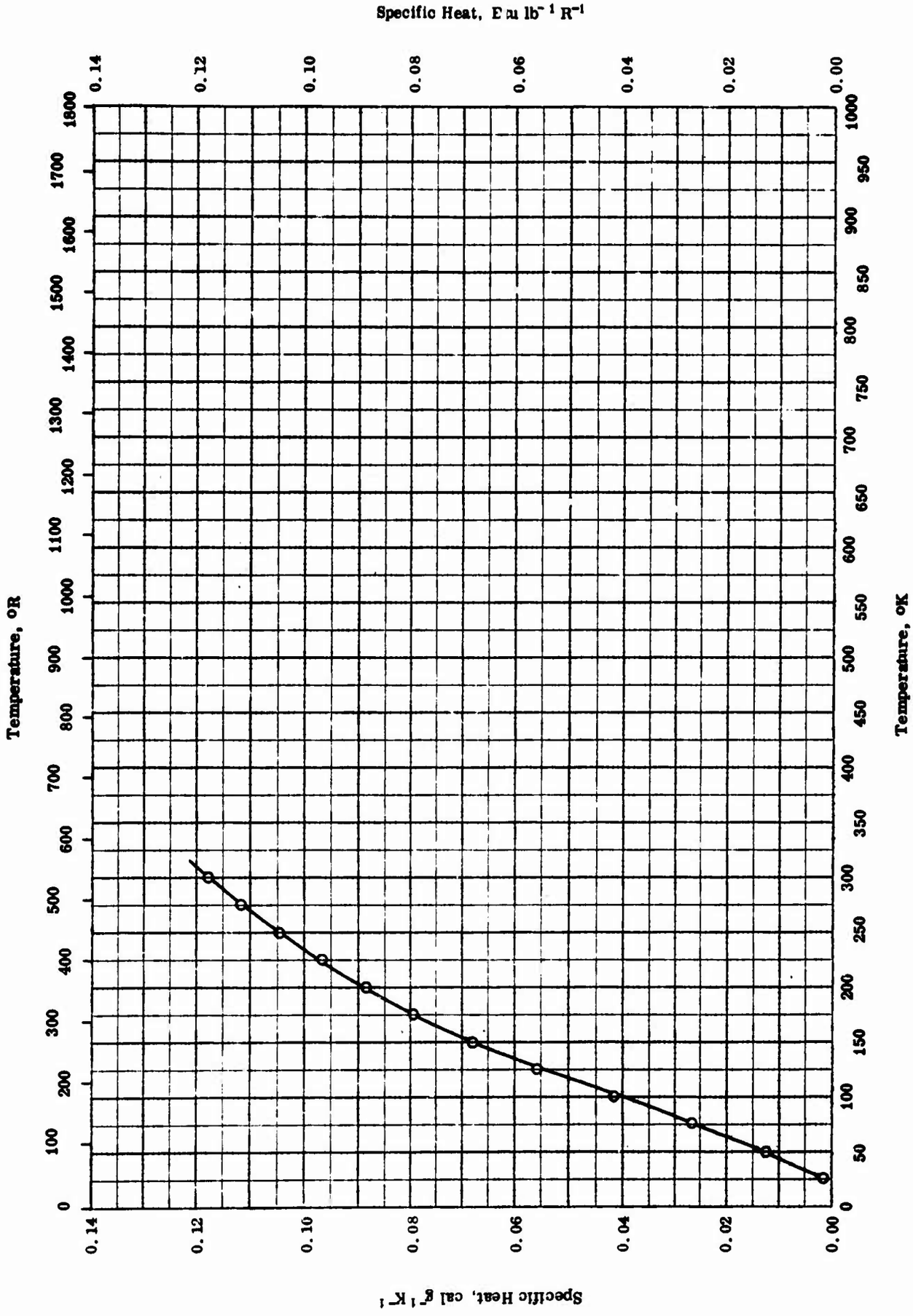
NORMAL SPECTRAL EMITTANCE -- GADOLINIUM OXIDE

TPRC

NORMAL SPECTRAL EMITTANCE -- GADOLINIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Wavelength μ	Temp. Range °K	Rept. Error%	Sample Specifications	Remarks
○	63-25	0.445	583-1673		Gd_2O_3.	Powdered material compressed to 75000 psi, fired at 1773 K for 24 hrs; ground to 0.125 in. thickness; measured in air; calculated from reflectance data; data taken from smooth curve.
△	63-25	0.488	533-1773		Same as above.	Same as above.
□	63-25	0.533	523-1733		Same as above.	Same as above.
◐	63-25	0.570	533-1813		Same as above.	Same as above.
▷	63-25	0.605	578-1823		Same as above.	Same as above.
●	63-25	0.680	623-1873		Same as above.	Same as above.

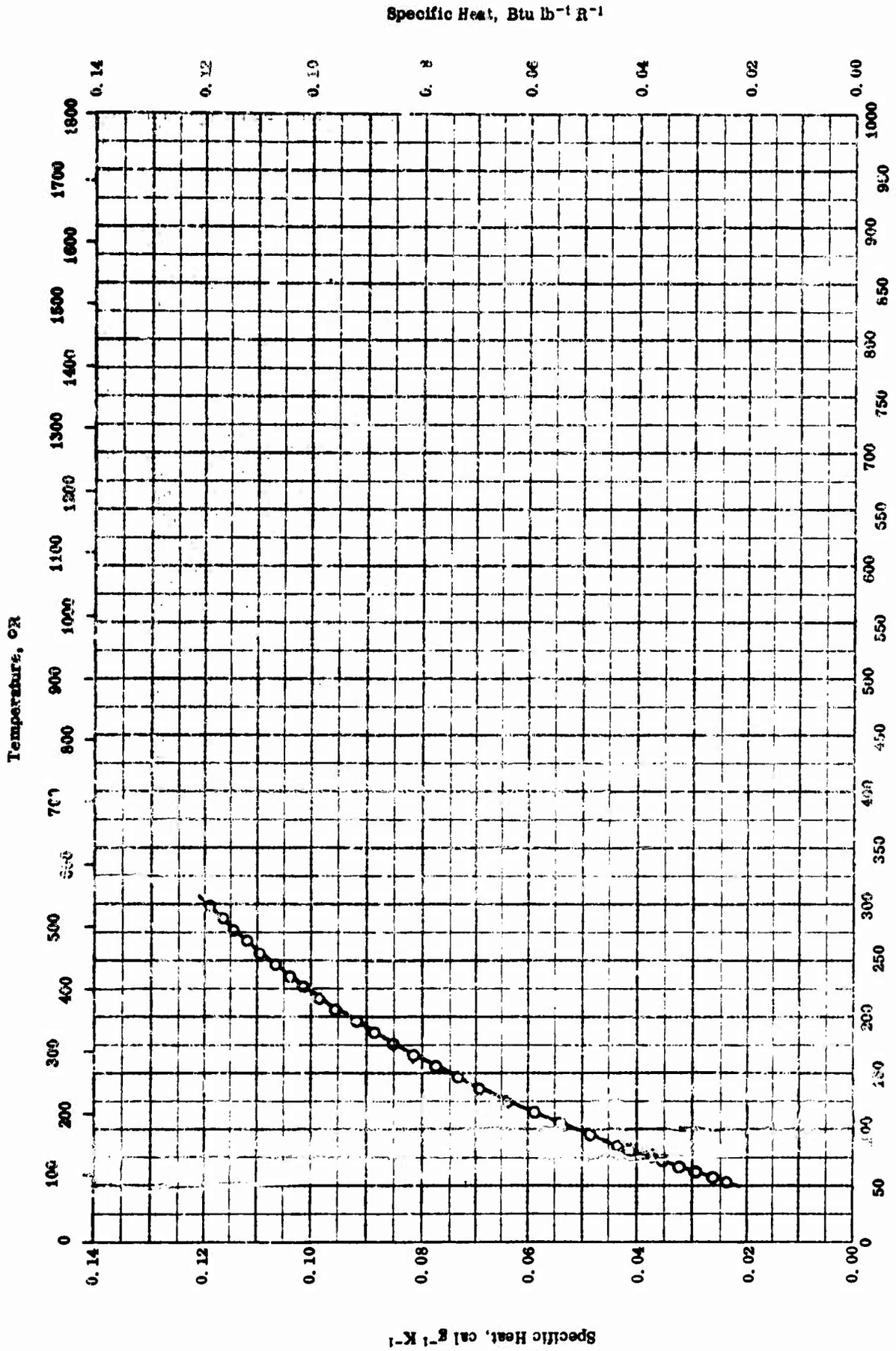


SPECIFIC HEAT — GALLIUM SESQUIOXIDE

SPECIFIC HEAT -- GALLIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	52-8	16-300		98.67 β Ga_2O_3, 1.16 SiO_2, 0.1 ZnO, 0.05 Al_2O_3, 0.05 Fe_2O_3, 0.02 SnO_2, 0.01 MgO, 0.008 CuO, and 0.001 each MnO, MoO_2, and PbO.	Corrected for impurities.

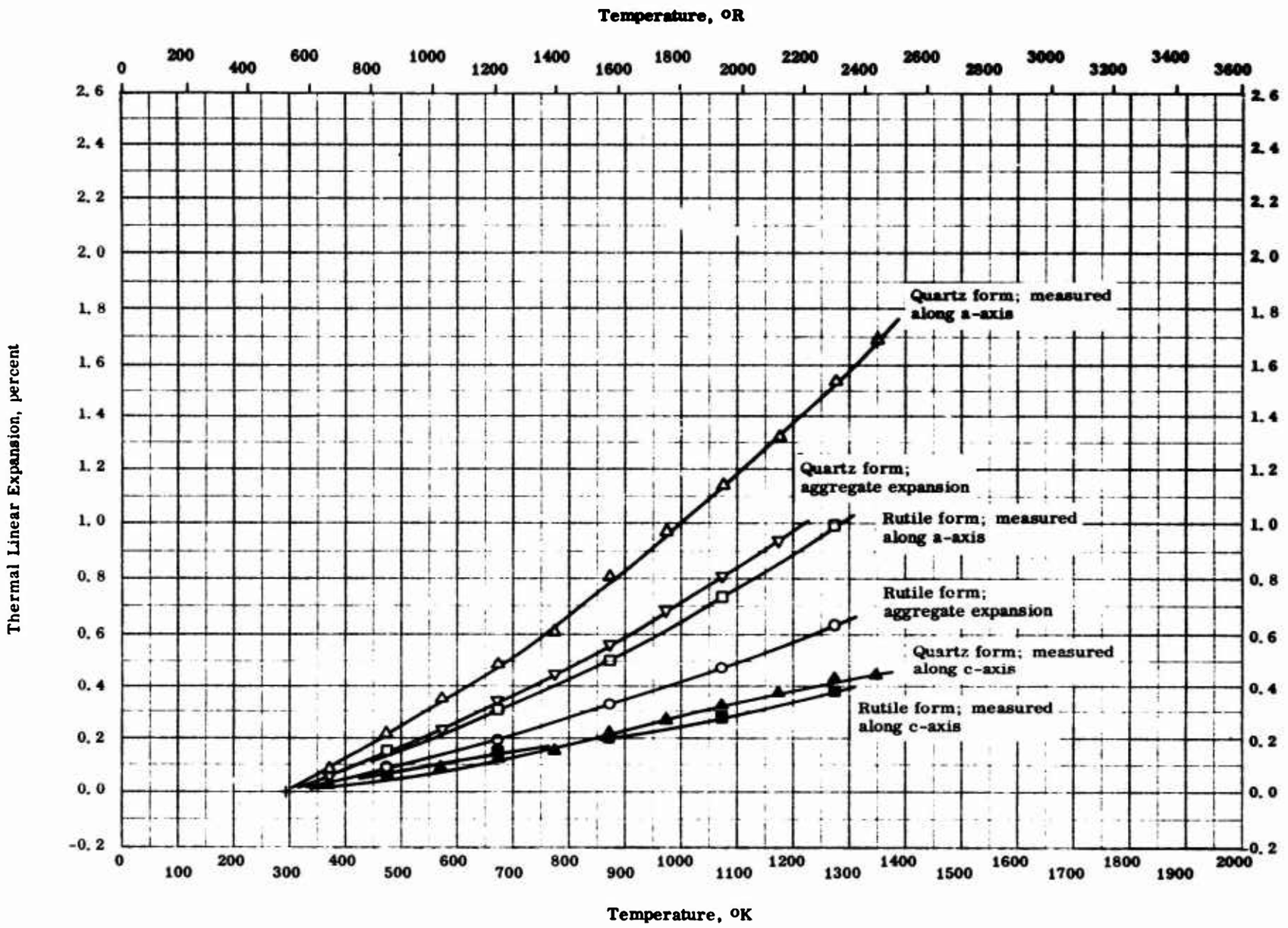


SPECIFIC HEAT -- GERMANIUM DIOXIDE

SPECIFIC HEAT -- GERMANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	58-9	53-298		99.99 GeO_2.	

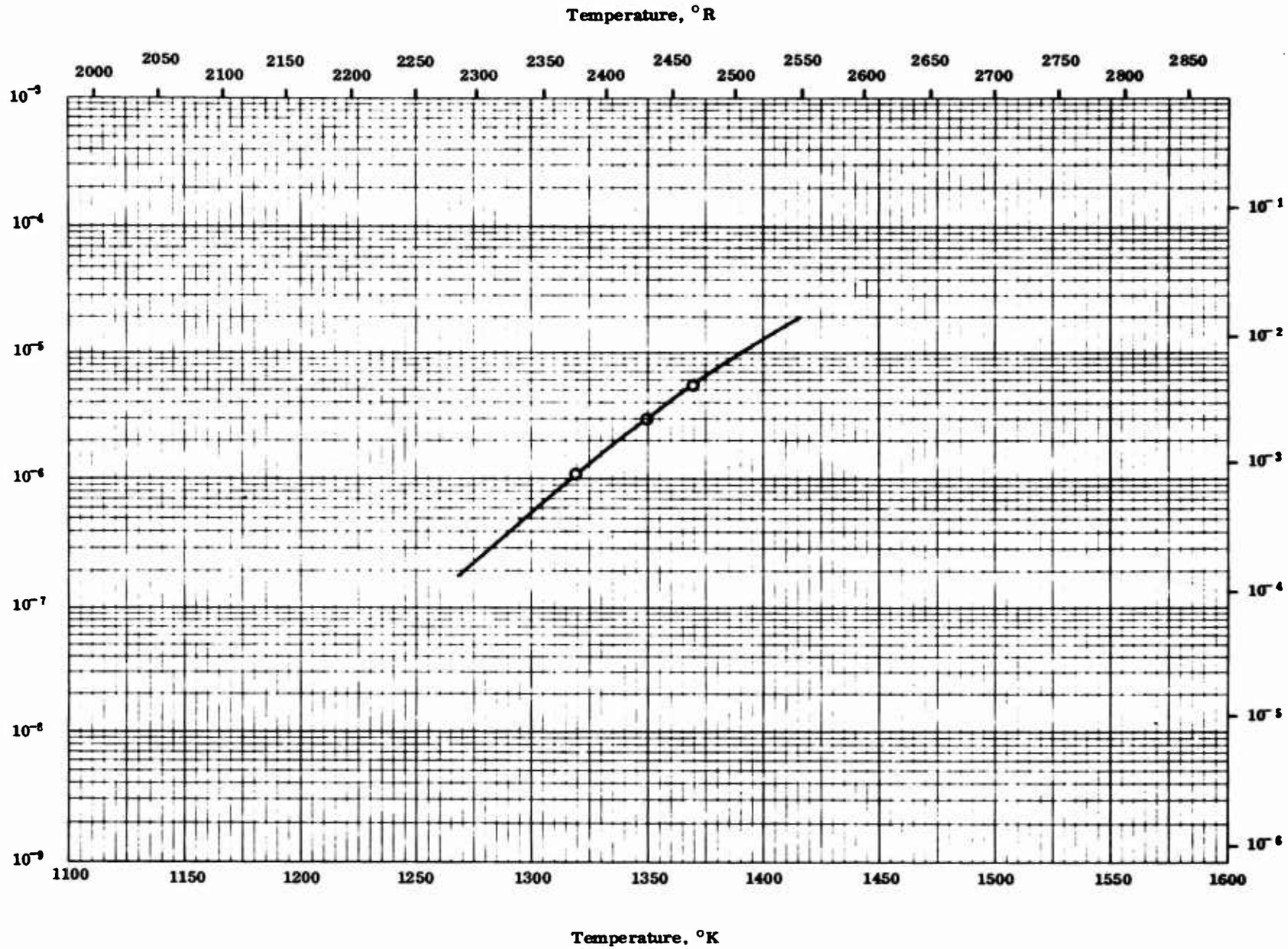


THERMAL LINEAR EXPANSION -- GERMANIUM DIOXIDE

THERMAL LINEAR EXPANSION -- GERMANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
△	61-42	303-1348		GeO_2; quartz form.	Sintered at 1100 C for 24 hrs; measured along a-axis with x-ray diffractometer.
▲	61-42	303-1348		Same as above.	Same as above except measured along c-axis.
▽	61-42	303-1173		Same as above; sample approx. 10 cm long.	Sintered at 1100 C for 24 hrs; aggregate expansion measured with heating rate of 2 C min^{-1}.
□	63-37	298-1273		GeO_2; rutile form.	Measured along a-axis with x-ray diffractometer.
■	63-37	298-1273		Same as above.	Same as above except measured along c-axis.
○	63-37	298-1273		Same as above; dimensions 1 by 1 by 10 cm.	Prepared by hydrothermal treatment of commercial germania with α-quartz structure; fired at 1000 C for 24 hrs; aggregate expansion.



TPRC

VAPOR PRESSURE -- GERMANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-11	1320-1370		99.99 pure GeO_2.	Author notes dissociation of GeO_2 into GeO + 1/2 O_2 in gas phase.

PROPERTIES OF HAFNIUM DIOXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	9.68	604
Melting Point	3173	5721

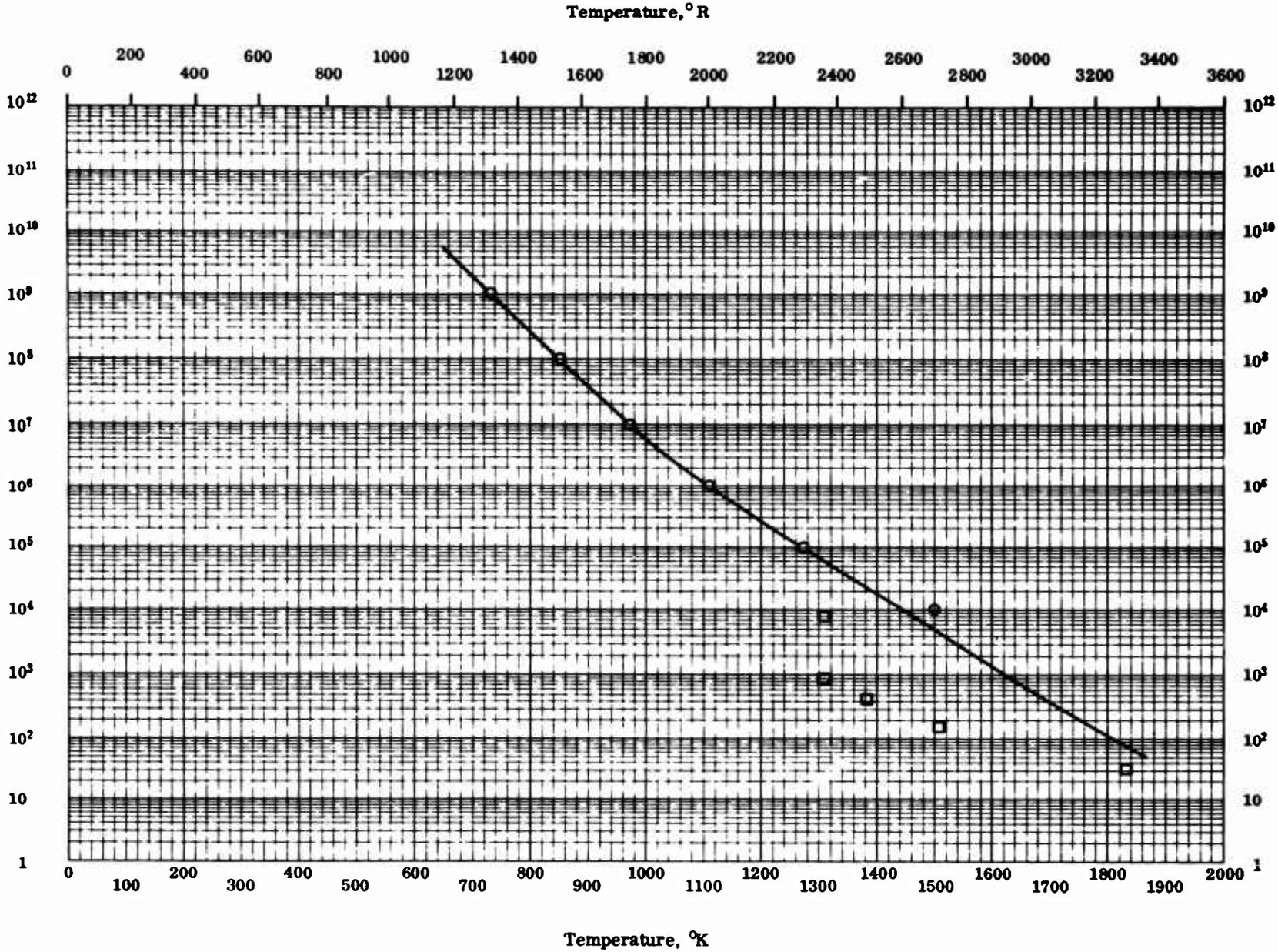
REPORTED VALUES

Melting Point	K	R
○	3173 ± 25	5721 ± 45
□	3085	5553

PROPERTIES OF HAFNIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-18	3178		0.1+ Ti, 0.06 Al, 0.01 each Fe and Si, and 0.0002 Zr.	Ground to 325 mesh, pressed at 20,000 psi, and fired 2 hrs at 1600 C.
□	49-3	3086		Not given.	



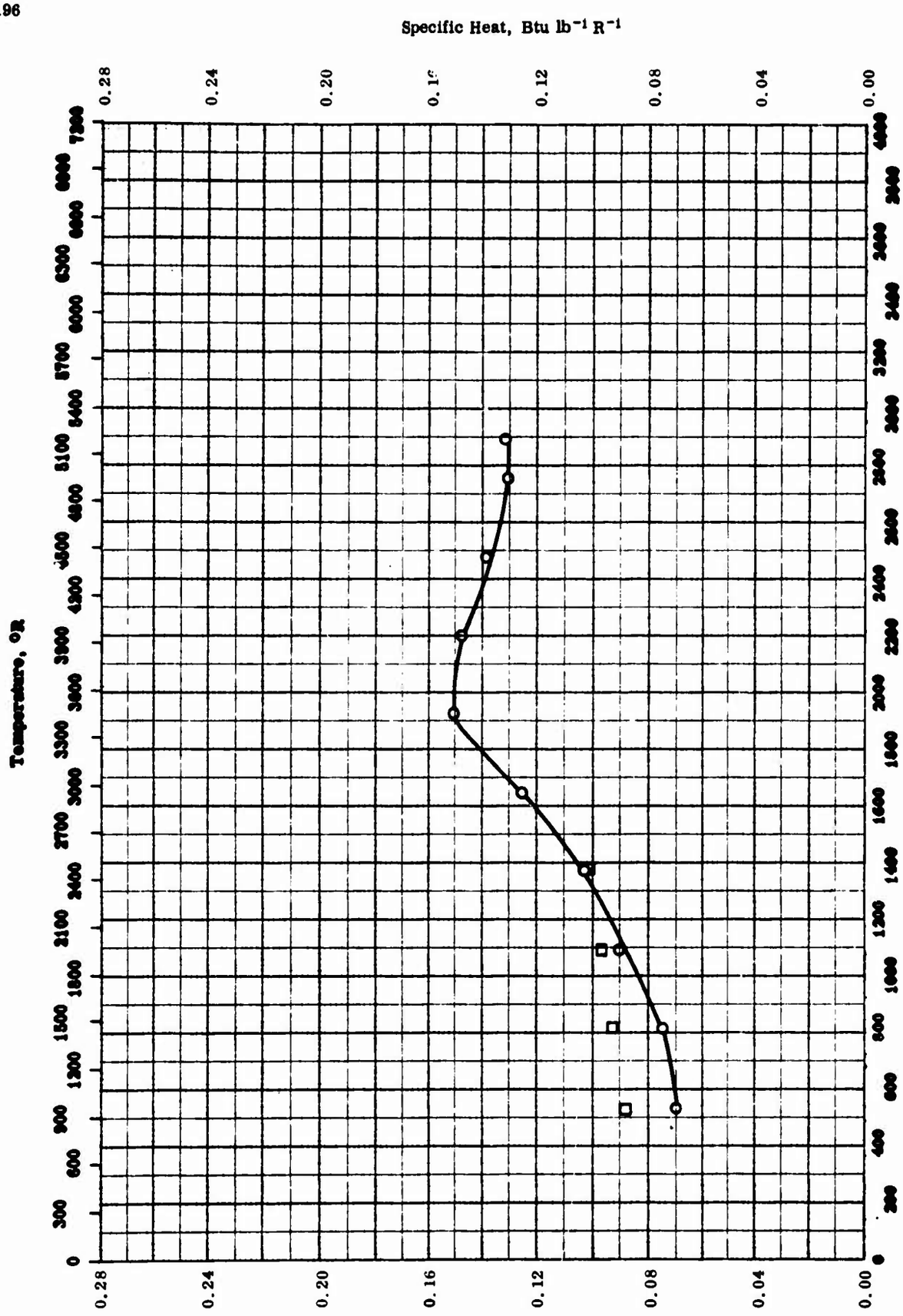
ELECTRICAL RESISTIVITY -- HAFNIUM DIOXIDE

Electrical Resistivity, ohm cm

ELECTRICAL RESISTIVITY -- HAFNIUM DIOXIDE

REFERENCE INFORMATION

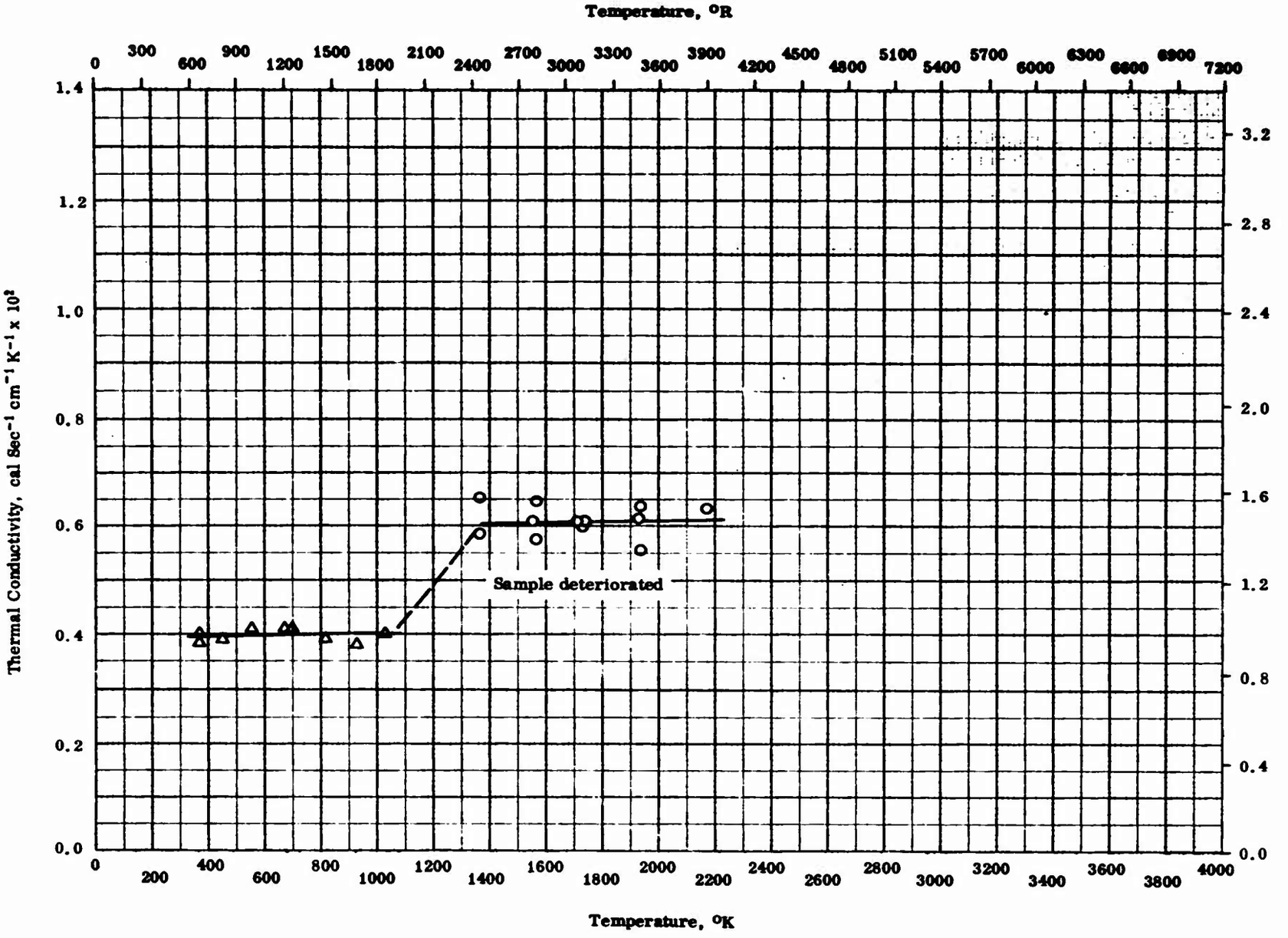
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-18	673-1773		Hafnium dioxide; 0.1 + Ti, 0.1 ea. Fe, Si, 0.06 Al, and 0.0002 Zr.	Work done at NBS; material ground to pass 325 mesh, pressed at 20,000 psi with 5% water and 2% dextrin; fired 2 hrs at 1600 C.
□	62-4	1311-1833	2.4	HfO_2; 82.0 Hf.	Pressed and sintered; max exposure temperature 4625 F.



SPECIFIC HEAT -- HAFNIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	62-4	533-2894	≤5.0	HfO_2; before test: 82.0 Hf, 2.5 Fe, 0.3 Mg, 0.10 Ca, 0.10 Ti; density 595 lb ft^{-3}; after test: 84.0 Hf, 0.51 C; density 601 lb ft^{-3}.	Crushed in a hardened steel mortar to pass 100-mesh screen; pressed and sintered.
□	61-17	422-1366	5.0	97.0 HfO_2, 2.3 Zr; density 524 lb ft^{-3}.	Sample made by spraying powdered ZrO_2 using powder gun with 90 ft^3 hr^{-1} N_2, 10 ft^3 hr^{-1} H_2, plasma gas, and 10 ft^3 hr^{-1} carrier gas.



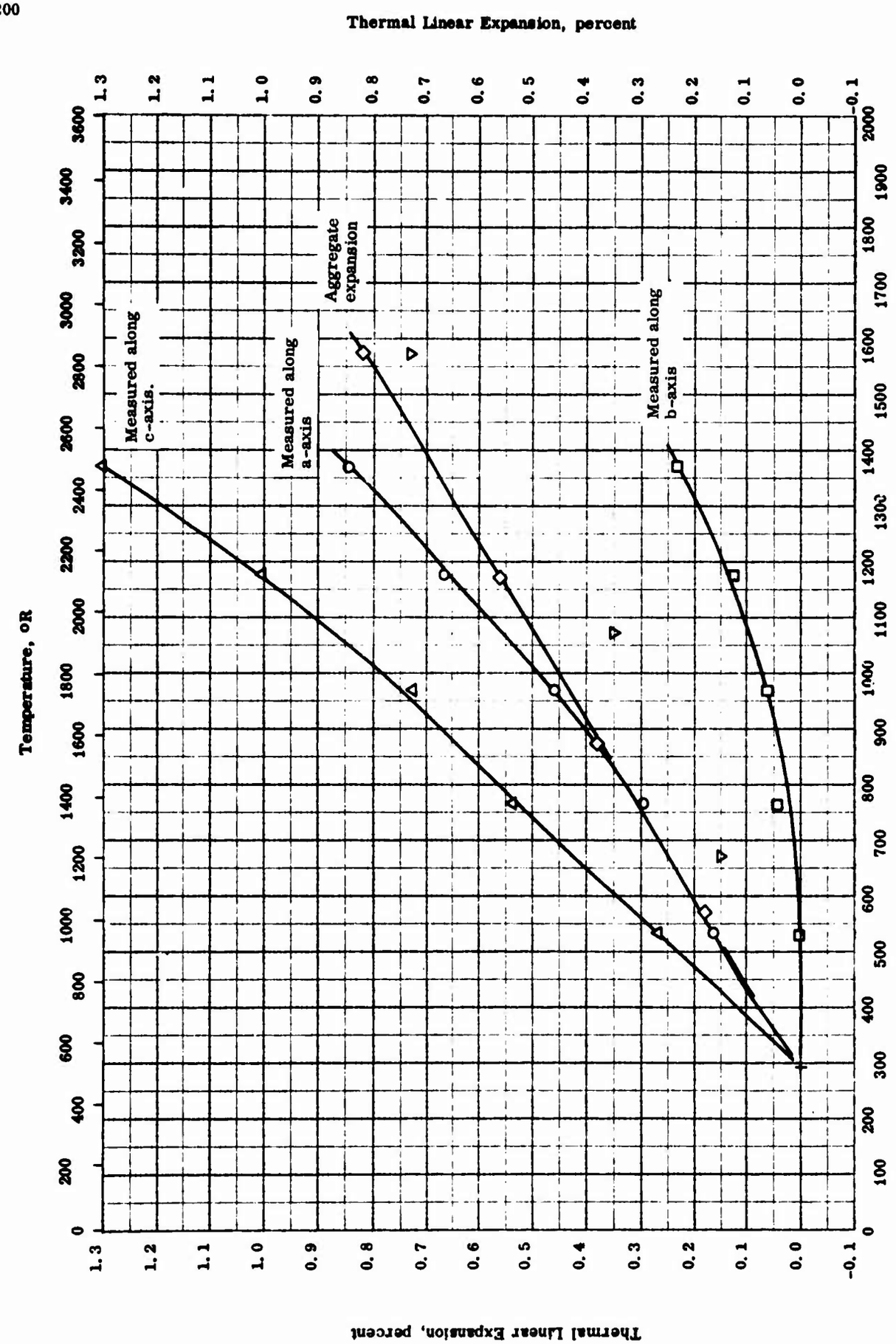
THERMAL CONDUCTIVITY -- HAFNIUM DIOXIDE

TPRC

THERMAL CONDUCTIVITY -- HAFNIUM DIOXIDE

REFERENCE INFORMATION

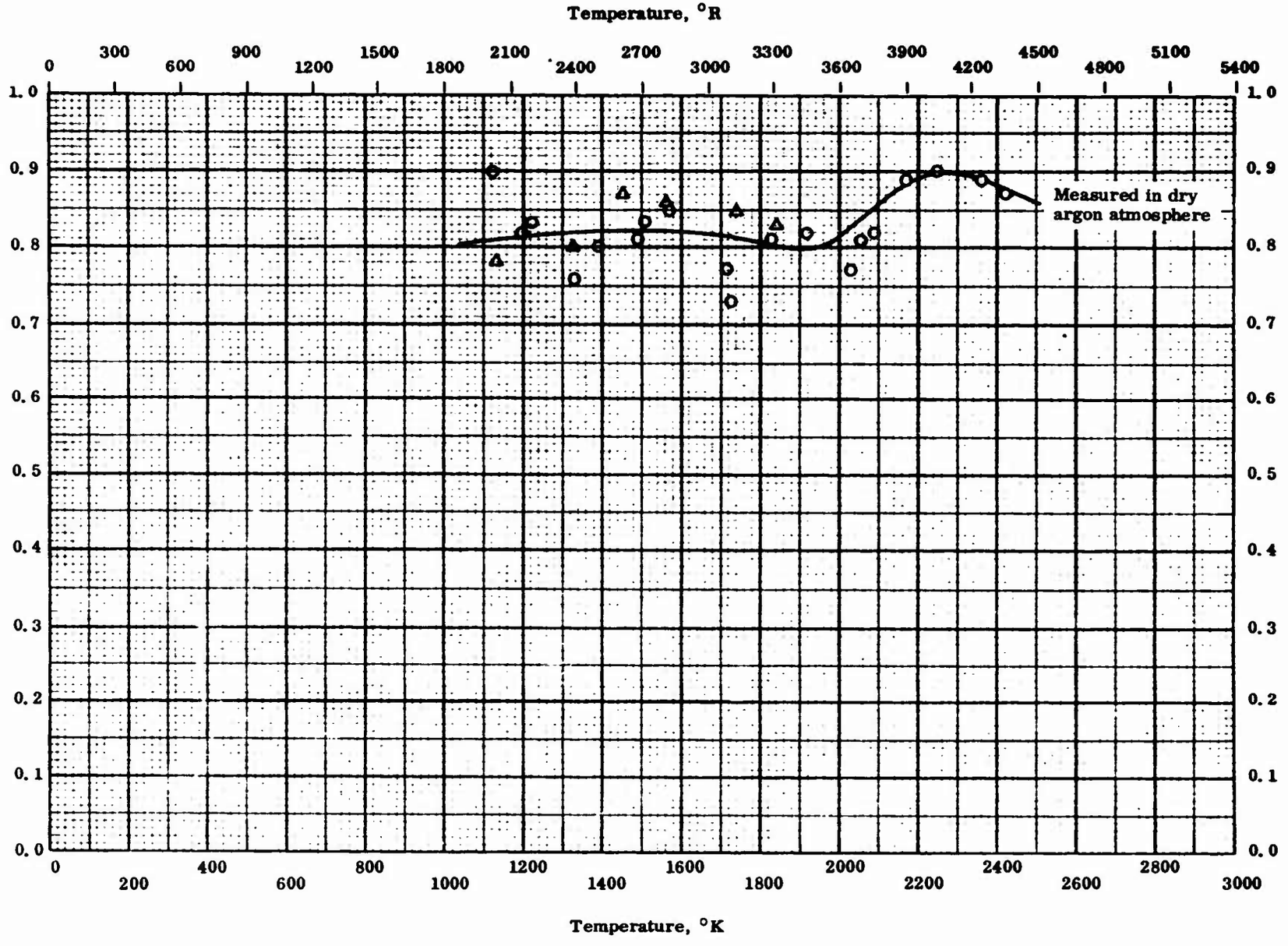
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
Δ	55-1	368-1033		HfO_2	
O	62-4	1365-2173	5-7	HfO_2	Ground and polished thoroughly; sample found deteriorated on post inspection.



THERMAL LINEAR EXPANSION -- HAFNIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-28	301-1371	2-3	99.5 HfO_2; 0.01 - 0.1 Zr, 0.003 - 0.03 Mg, Si, 0.001 - 0.01 Al, Ca, and trace of Cr, Cu, and Fe; monoclinic.	Mixture of HfO_2 with approx. 35 Pt powder fired at 1500 C for 24 hrs, cooled, and ground; Pt powder used for furnace alignment and thermal calibration; measured along a-axis with x-ray diffractometer.
□	62-28	301-1371	2-3	Same as above.	Same as above except measured along b-axis.
△	62-28	301-1371	2-3	Same as above.	Same as above except measured along c-axis.
◇	54-18	293-1573		Unstabilized hafnia; 0.1+ Ti, 0.1 Fe, Si, 0.06 Al, and 0.0002 Zr; monoclinic.	Ground to 325 mesh, pressed at 20,000 psi, and fired 2 hrs at 1600 C; measured with heating rate of 3 C min^{-1}.
▽	57-36	672-1572		Unstabilized hafnia; Zr free; monoclinic.	

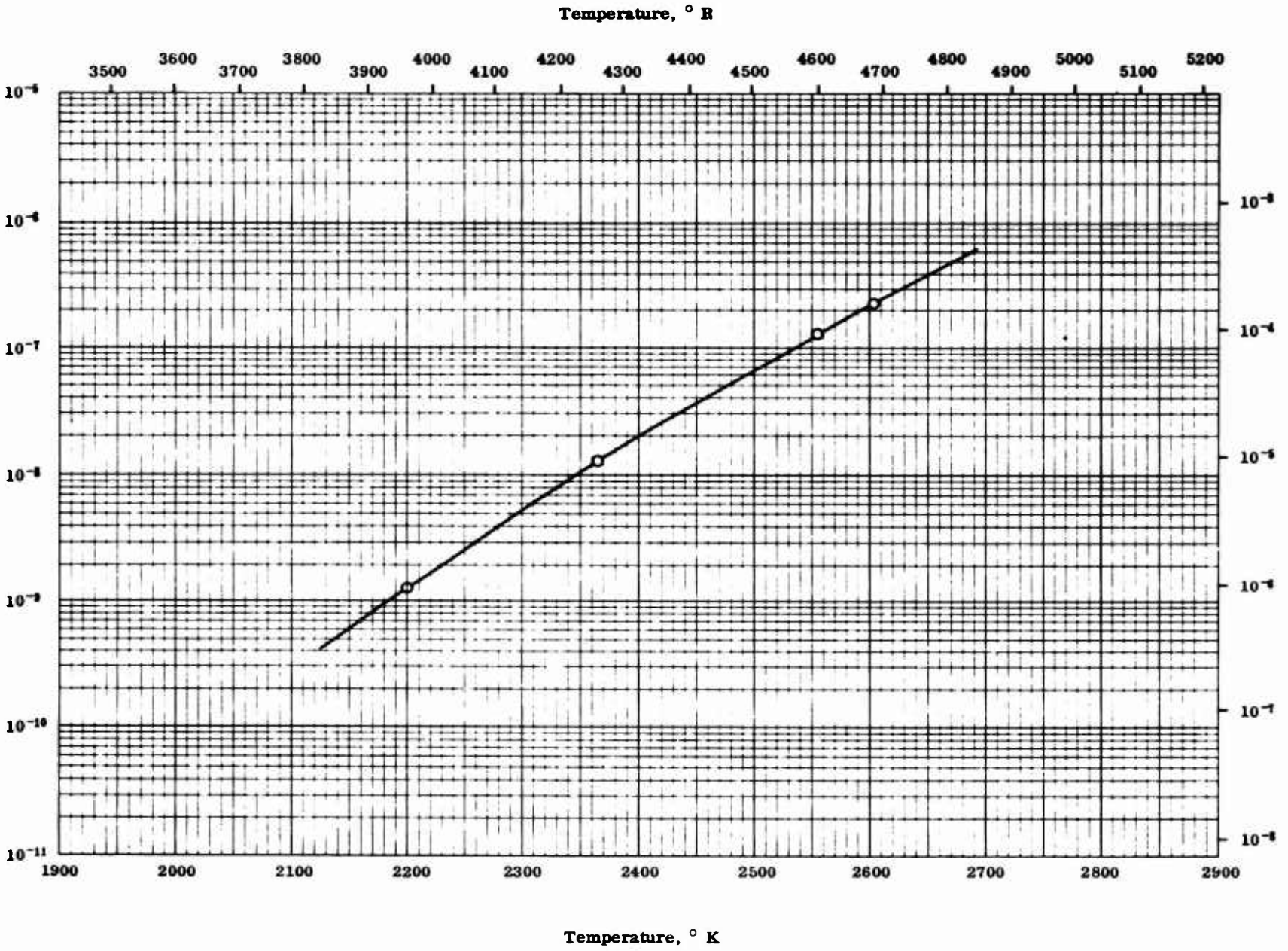


NORMAL TOTAL EMITTANCE — HAFNIUM DIOXIDE

NORMAL TOTAL EMITTANCE -- HAFNIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	62-4	1122-2422	10	HfO_2; density 9.55 g cm^{-3}.	Pressed and sintered; measured in dry argon atmosphere; run No. 1.
Δ	62-4	1138-1843	10	Same as above.	Same as above; run No. 2.



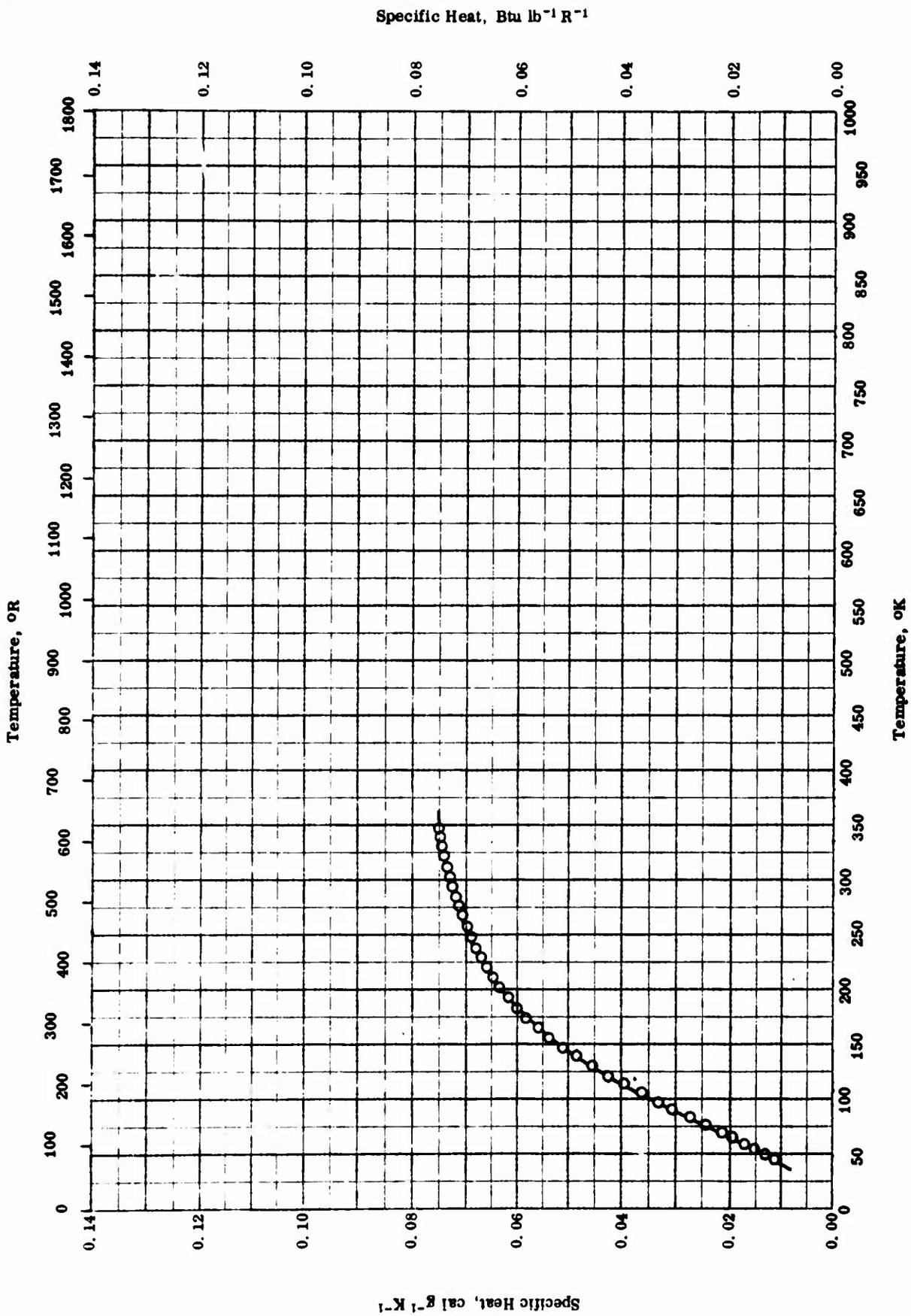
VAPOR PRESSURE -- HAFNIUM DIOXIDE

TPRC

VAPOR PRESSURE -- HAFNIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	61-9	2200-2603		HfO_2.	Hf^{181} used as tracer.

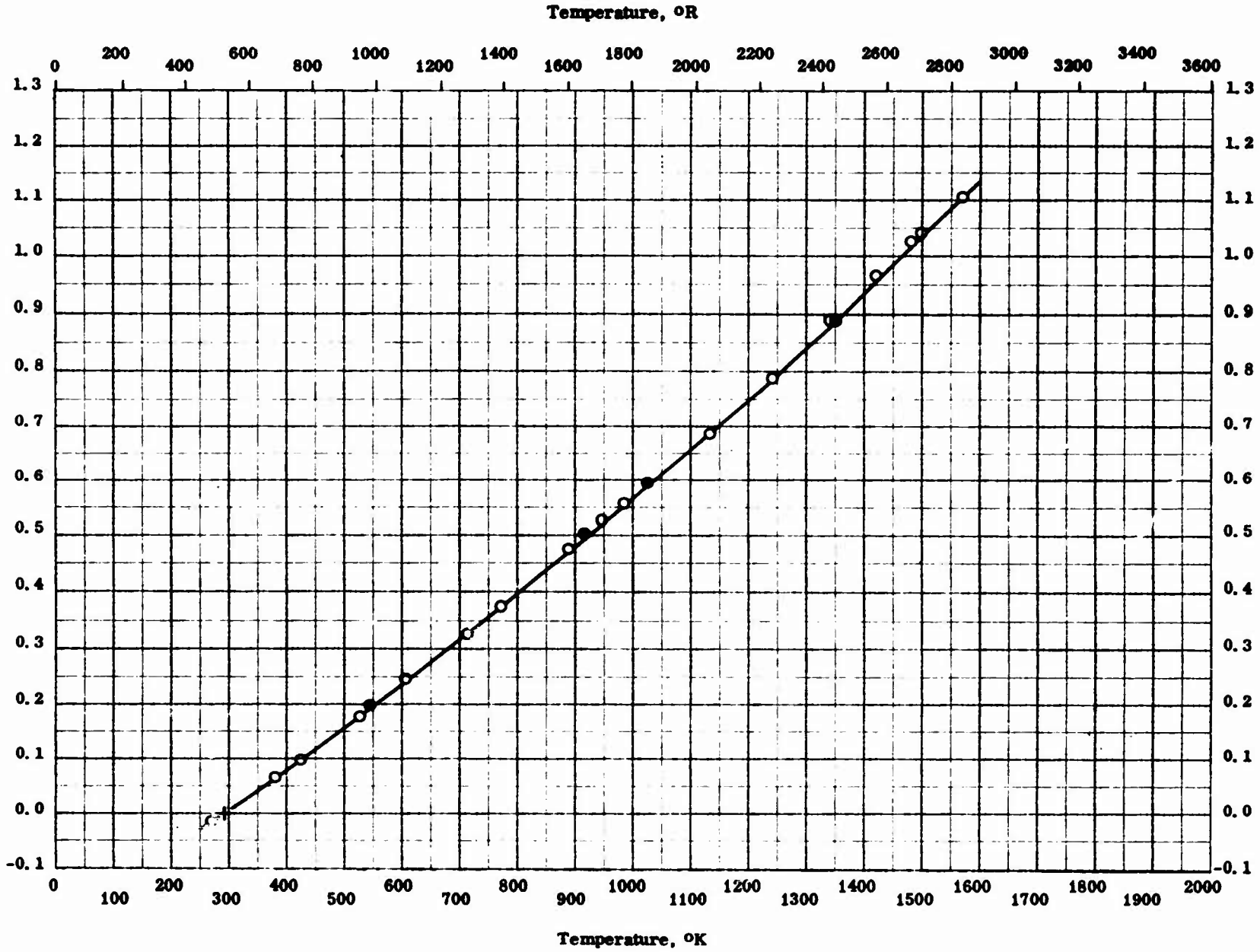


SPECIFIC HEAT -- HOLMIUM OXIDE

SPECIFIC HEAT -- HOLMIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	61-13 also 63-19	6-346	0.1	99.9 Ho_2O_3, 0.010 Ca, 0.010 Er, and 0.010 Si.	Powder specimen; in helium atm.



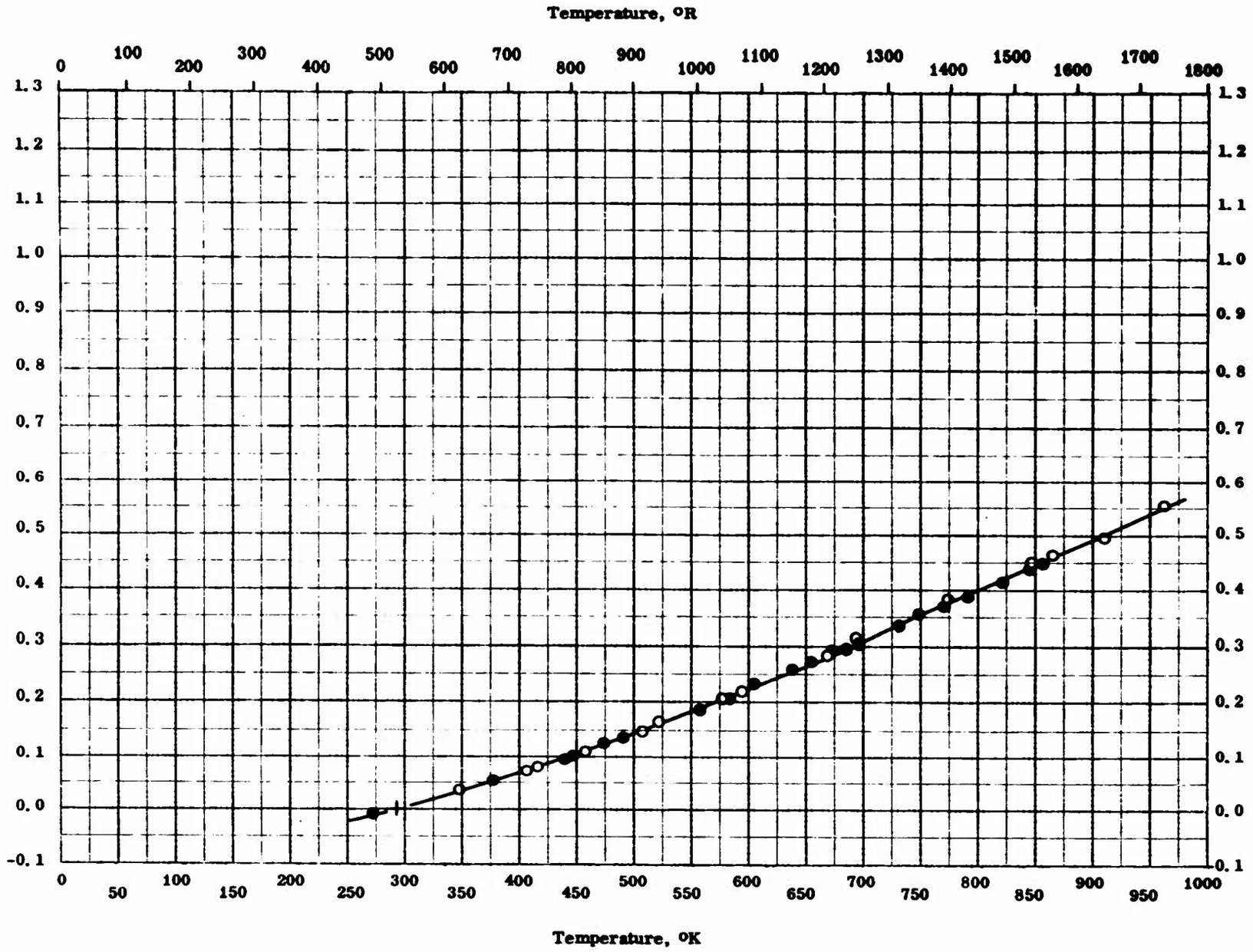
THERMAL LINEAR EXPANSION -- HOLMIUM OXIDE

TPRC

THERMAL LINEAR EXPANSION -- HOLMIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-41	273-1568	1.1-6.0	Ho_2O_3 from Michigan Chemical Co., St. Louis, Mich.; 99.9 Ho_2O_3 in regard to total rare-earth content; 0.01-0.1 Er, 0.003 - 0.03 Ca, 0.001 - 0.01 Mg, Si, 0.0003 - 0.003 Fe, Yb, Y, and 0.0001 - 0.001 Al; cubic, rare-earth oxide type C.	Sintered at 1300 C for 24 hrs, packed into alumina sample holder, resintered at 1300 C for 24 hrs, cooled to 200 C, and placed in a vacuum desiccator for storage; x-ray diffractometer method.
●	61-41	547-1568	1.1-6.0	Same as above.	Cooling cycle for above sample.



THERMAL LINEAR EXPANSION -- INDIUM SESQUIOXIDE

THERMAL LINEAR EXPANSION -- INDIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	63-39	273-961		In_2O_3; approx. 55% theoretical density.	Sintered material prepared by pressing indium sesquioxide into pellet form and heating in air at approx. 1500 C for 24 hrs; author's absolute error in determining $\Delta L/Lo$ is about 10^{-4}.
●	63-39	273-860		In_2O_3; single crystal.	

PROPERTIES OF FERROFERRIC OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	314	5.03
Melting Point	1811*	3260*

*Handbook of Chemistry and Physics. (Ref. 64-16)

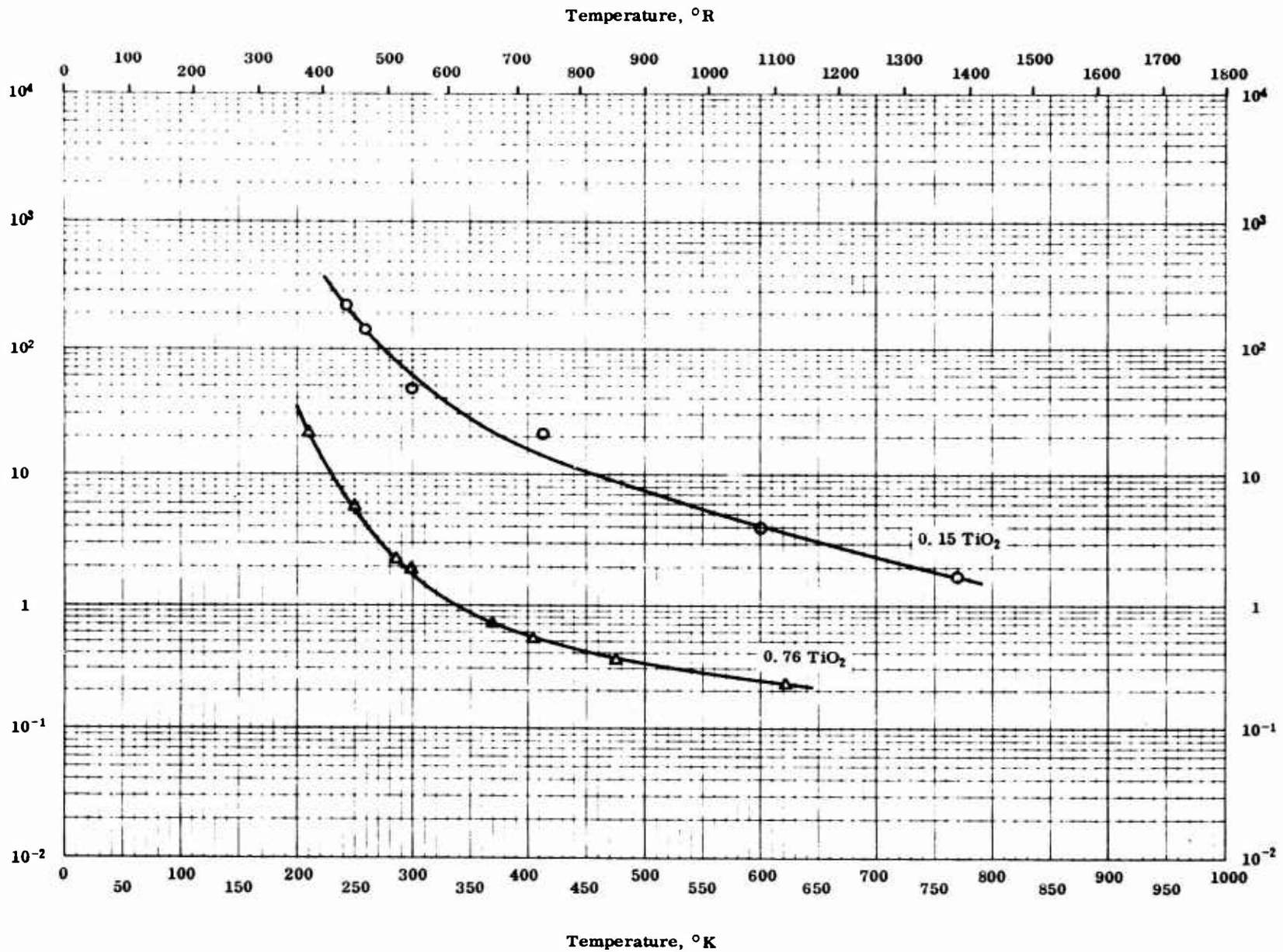
REPORTED VALUES

Density	g cm^{-3}	lb ft^{-3}
○	5.03	314
□	5.01	313
△	5.06	316

PROPERTIES OF FERROFERRIC OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	55-30	298		Magnetite, Fe_3O_4.	Prepared from high purity iron oxide heated 5 hrs at 800 C and fired in Co-CO_2.
□	55-30	298		Same as above.	Same as above except fired in CO_2.
△	55-30	298		Same as above.	Same as above except fired in He.

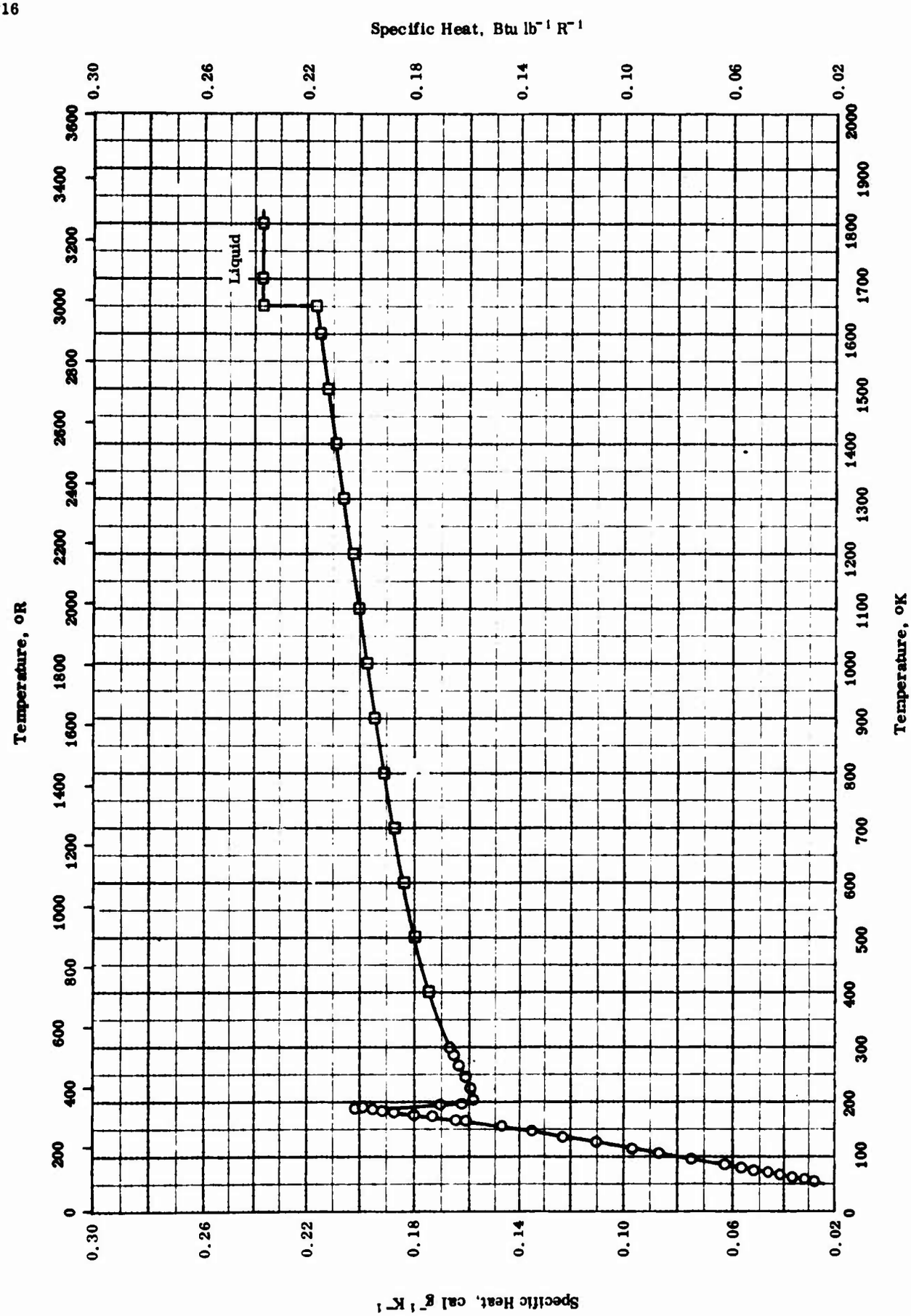


ELECTRICAL RESISTIVITY -- IRON (IC) OXIDE

ELECTRICAL RESISTIVITY -- IRON (IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	60-19	243-769		99.85 Fe_2O_3 and 0.15 TiO_2.	
Δ	60-19	210-621		99.24 Fe_2O_3 and 0.76 TiO_2.	

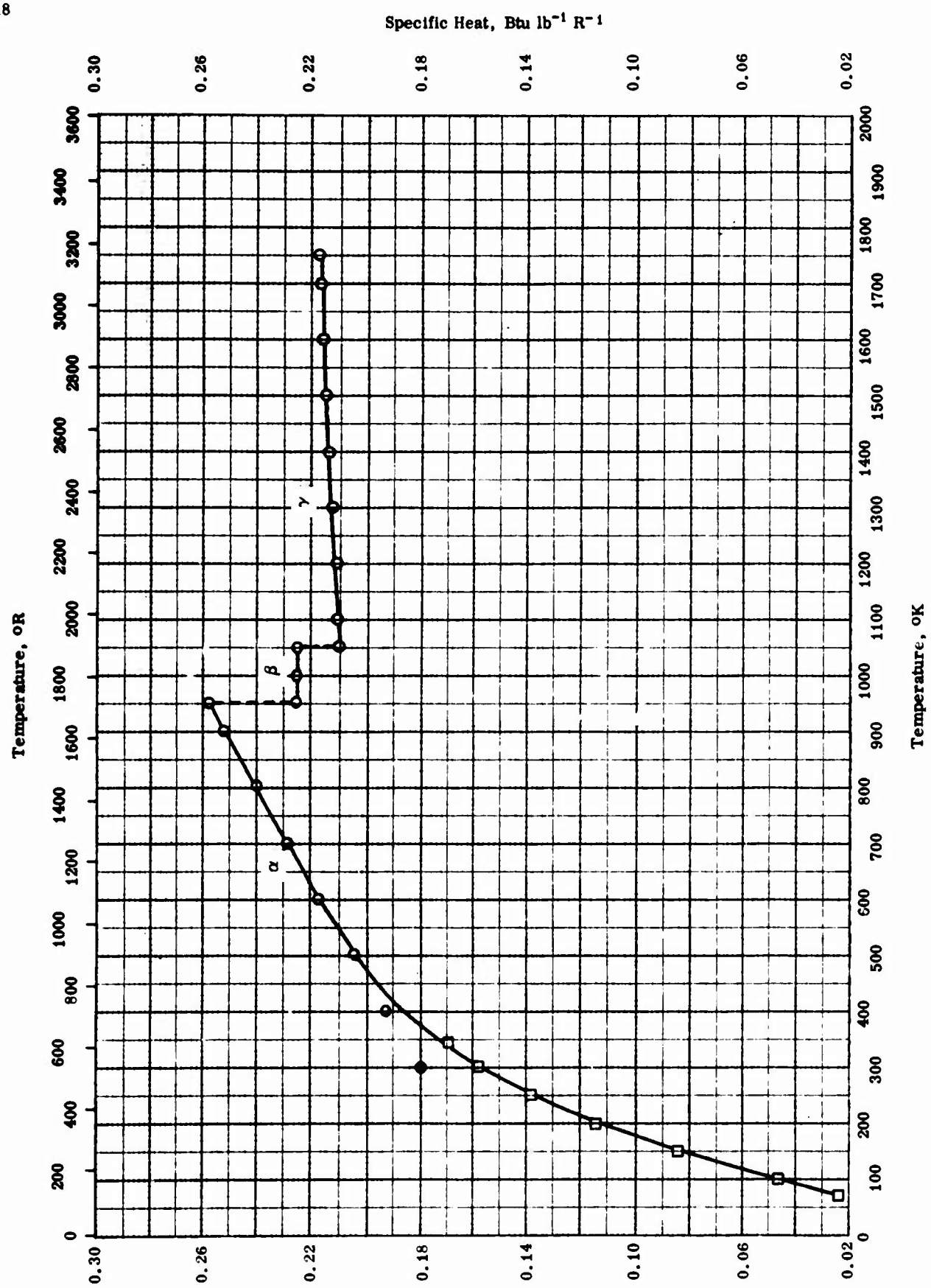


SPECIFIC HEAT -- IRON (OUS) OXIDE

SPECIFIC HEAT -- IRON (OUS) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	51-11	54-298		$Fe_{0.947}O$; 76.60 Fe, 23.18 O_2, and 0.17 SiO_2.	
□	51-8	340-1784		$Fe_{0.947}O$; 76.60 Fe, 23.18 O_2, and 0.17 SiO_2.	Heated 4.9 to 9.3 days at 1150 K and quenched.

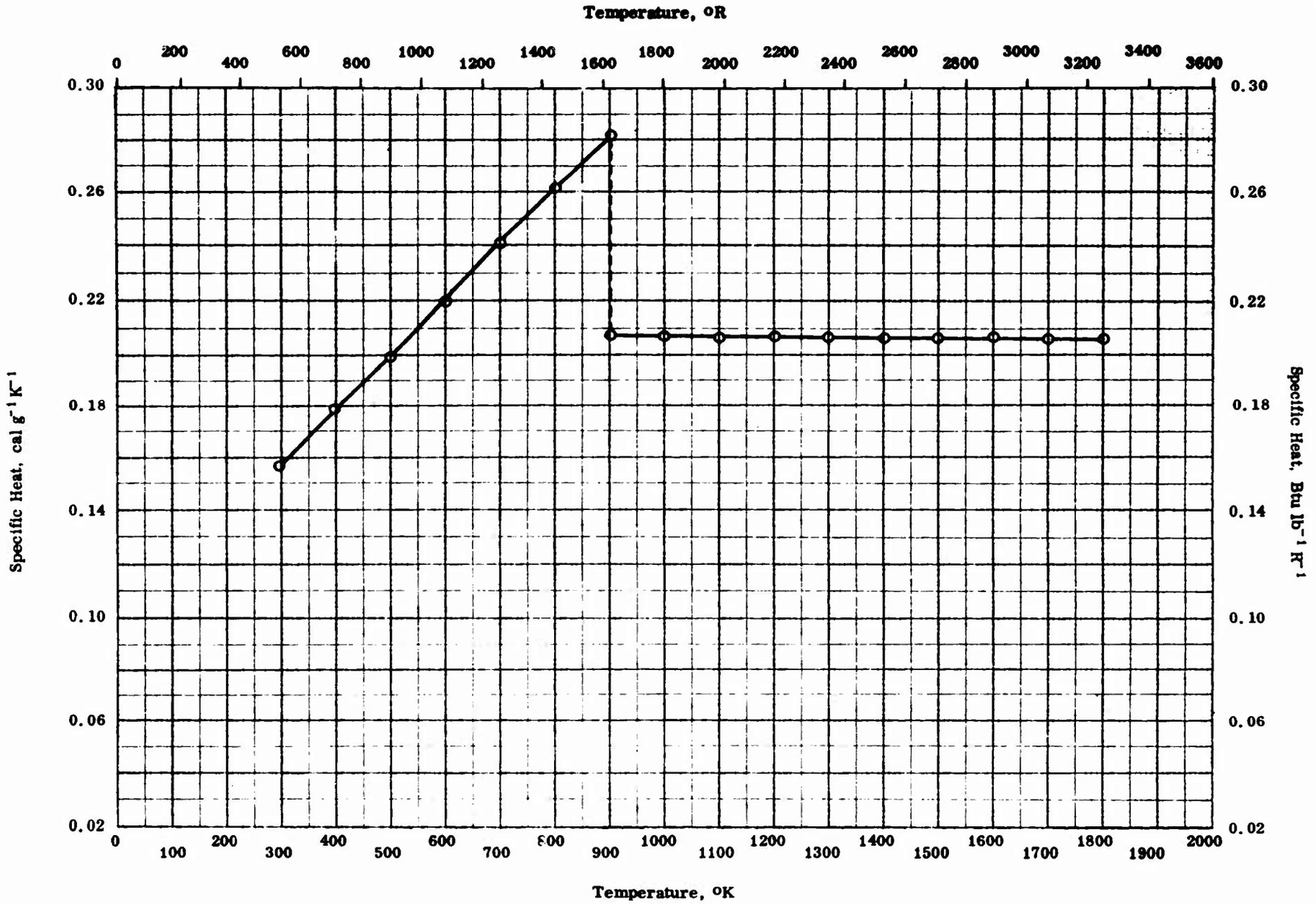


SPECIFIC HEAT -- IRON (IC) OXIDE

SPECIFIC HEAT -- IRON (IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	51-8	351-1825		Ferric oxide, Fe_2O_3, with 69.86 Fe; prepared from reagent grade $FeCl_3$.	
□	59-8	5-350		Fe_2O_3; 0.01 Mn, 0.01>Al, Co, Mg, Ni and Si, 0.001 Ca, Cu and Sn.	

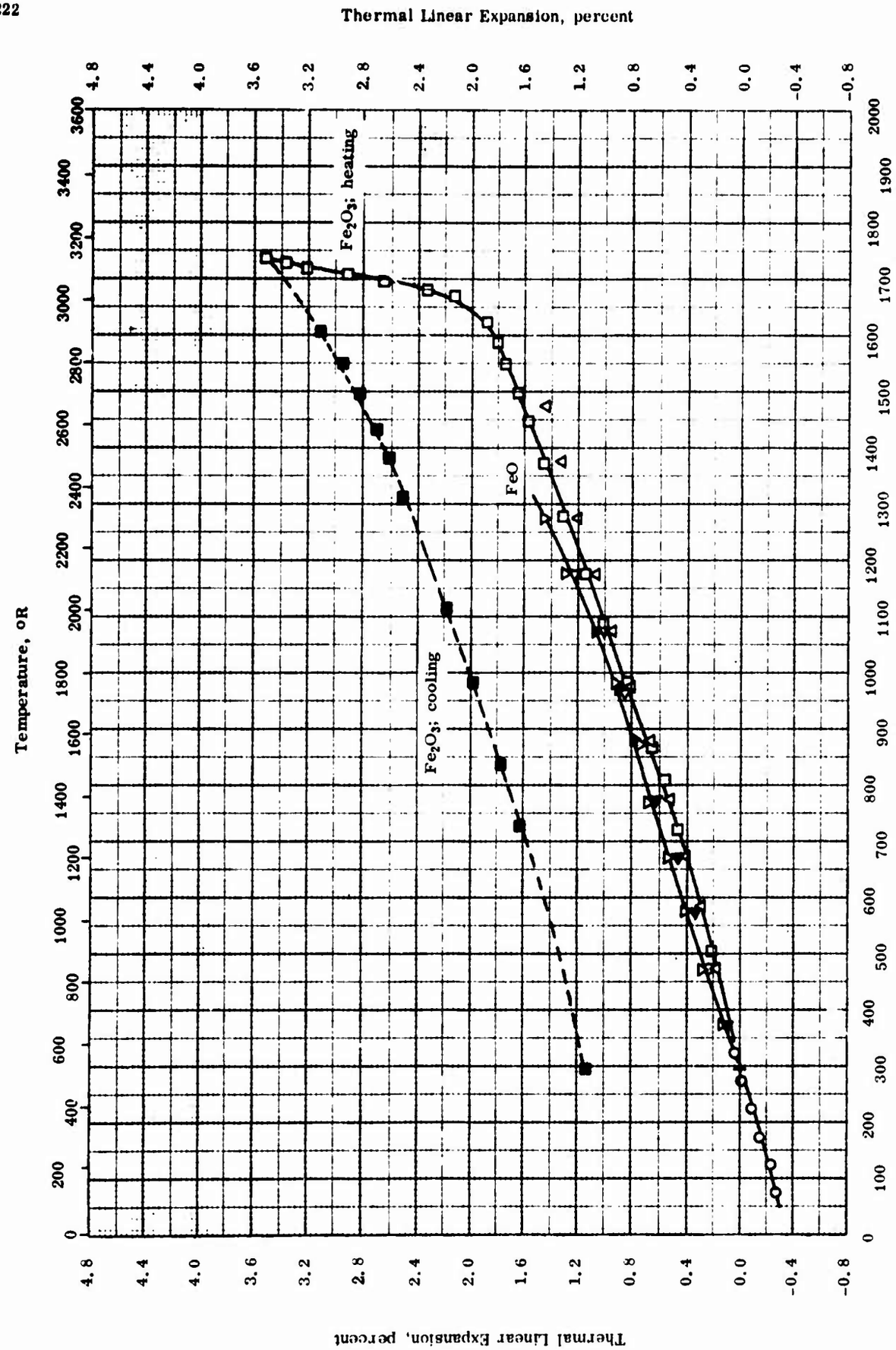


SPECIFIC HEAT -- FERROFERRIC OXIDE

SPECIFIC HEAT -- FERROFERRIC OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	51-8	298-1800		Magnetite, Fe_3O_4; 72.16 Fe, 27.54 O_2, and 0.22 SiO_2.	Prepared from ferric oxide by heating 8 hrs at 1630 K under vacuum.

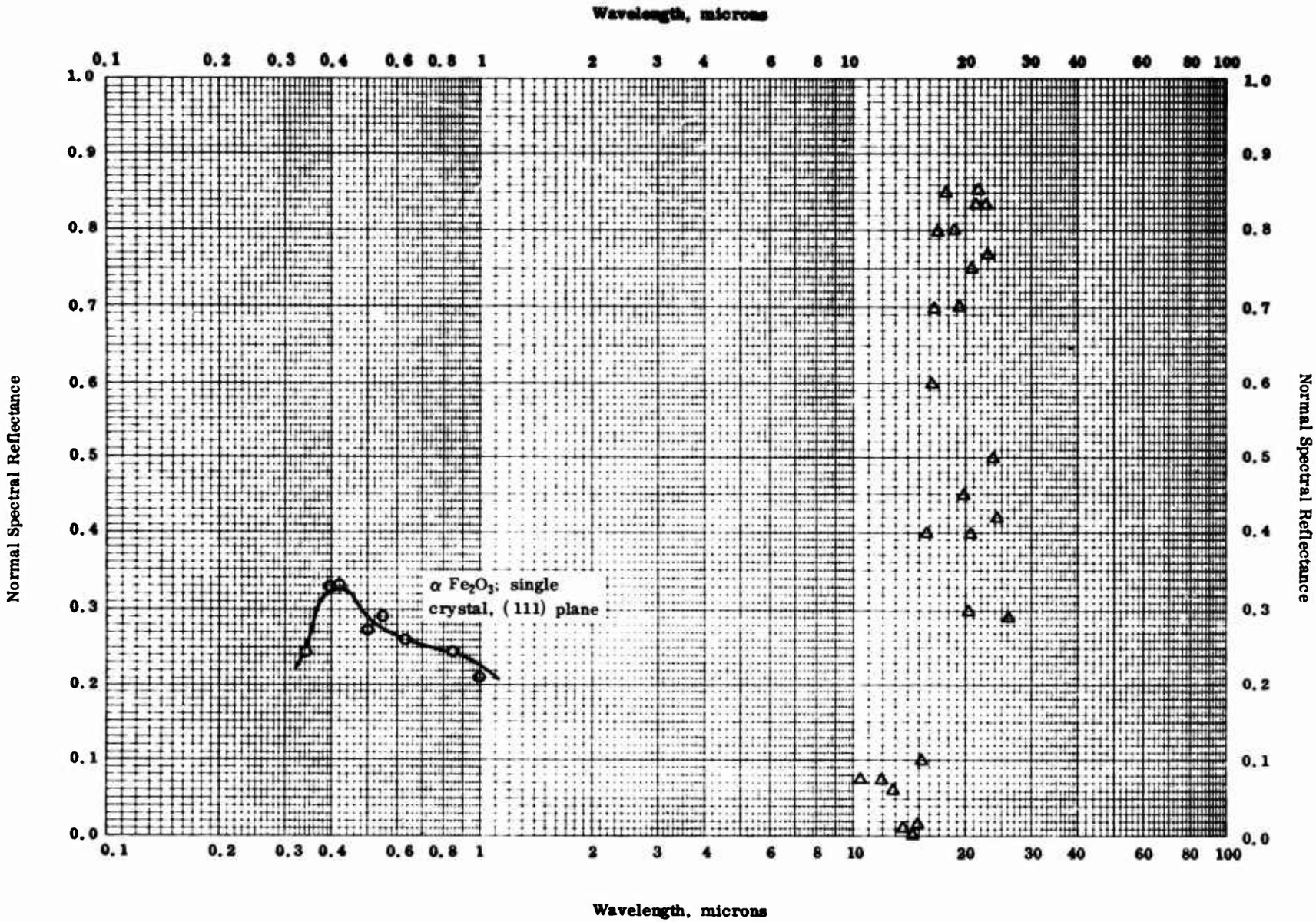


THERMAL LINEAR EXPANSION -- IRON OXIDES

THERMAL LINEAR EXPANSION -- IRON OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▽	59-21	298-1273		FeO, Wustite; prepared from 99.7 pure Fe_2O_3. [Author's design: Run 1]	Fe_2O_3 decomposed in platinum boat at 1000 C for 15 hrs in a H_2O : H ratio 0.88 atm , quenched in same atm , ground and mixed with 2% Carbowax 4000, pressed into a bar, sintered, and quenched under same conditions as before; measured with increasing temperature by placing the specimen in dilatometer, flushing with nitrogen, passing in the H_2O : H atm , and then heating the furnace and measuring expansion; H_2O : H ratio held at 0.32 up to 560 C and then with increasing temperature gradually raised to 0.88 at 1000 C.
▼	59-21	879-1273		Same as above.	Cooling cycle for above sample.
◁	59-21	298-1273		Same as above. [Author's design: Run 2]	Second heating cycle for above sample.
◀	59-21	373-1273		Same as above.	Second cooling curve for above sample.
○	48-9	73-673		FeO.	Measured in N_2 atm.
□	64-22	298-1733		Fe_2O_3; dimensions 2 cm in diameter by 7 cm long.	Prepared from ferrous oxalate calcined at 1000 C, finely-divided, bonded with dextrin and water, compacted into cylinders, and fired; measured in air atm with heating rate of 10 C min^{-1}.
■	64-22	293-1733		Same as above.	Cooling cycle for above sample.
△	46-5	373-1473		Fe_2O_3; density 326 lb ft^{-3}.	



NORMAL SPECTRAL REFLECTANCE -- IRON (IC) OXIDE

NORMAL SPECTRAL REFLECTANCE -- IRON (IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	60-28	298	0.344-1.0		α Fe_2O_3, single crystal; (111) plane.	Measured in air; data taken from smooth curve.
△	60-28	298	10.47-25.97		α Fe_2O_3, hematite crystal.	Polished section of unknown orientation cut; measured in air; data taken from smooth curve.

PROPERTIES OF LANTHANUM OXIDES

MOST PROBABLE VALUES

Property	C.G.S. Ur	Brit. Eng. Units
Density	6.56*	409*
Melting Point	2483	4470

*For La_2O_3 - A.

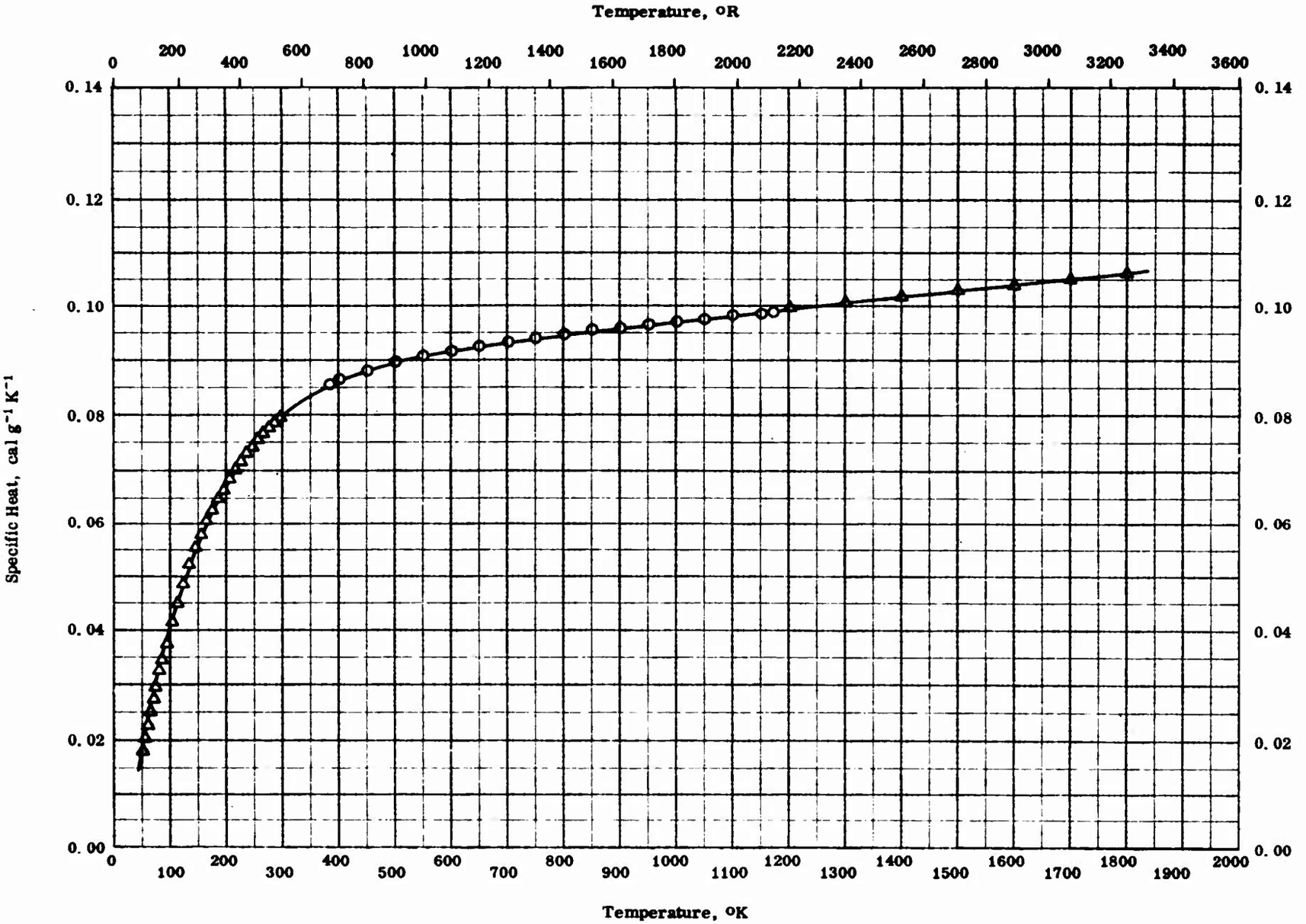
REPORTED VALUES

Density	g cm^{-3}	lb ft^{-3}
□ LaO	7.114	443.9
△ La_2O_3 - A	6.56	409.3
▽ La_2O_3 - C	5.84	364.4
Melting Point	**K**	**R**
○ La_2O_3.	2483 ± 20	4470 ± 36

PROPERTIES OF LANTHANUM OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-15	2463-2503		99 La_2O_3.	M. P. by inspecting after heating in constant temperature furnace.
□	62-16	298		LaO.	
△	62-16	298		La_2O_3 - A.	
▽	62-16	298		La_2O_3 - C.	



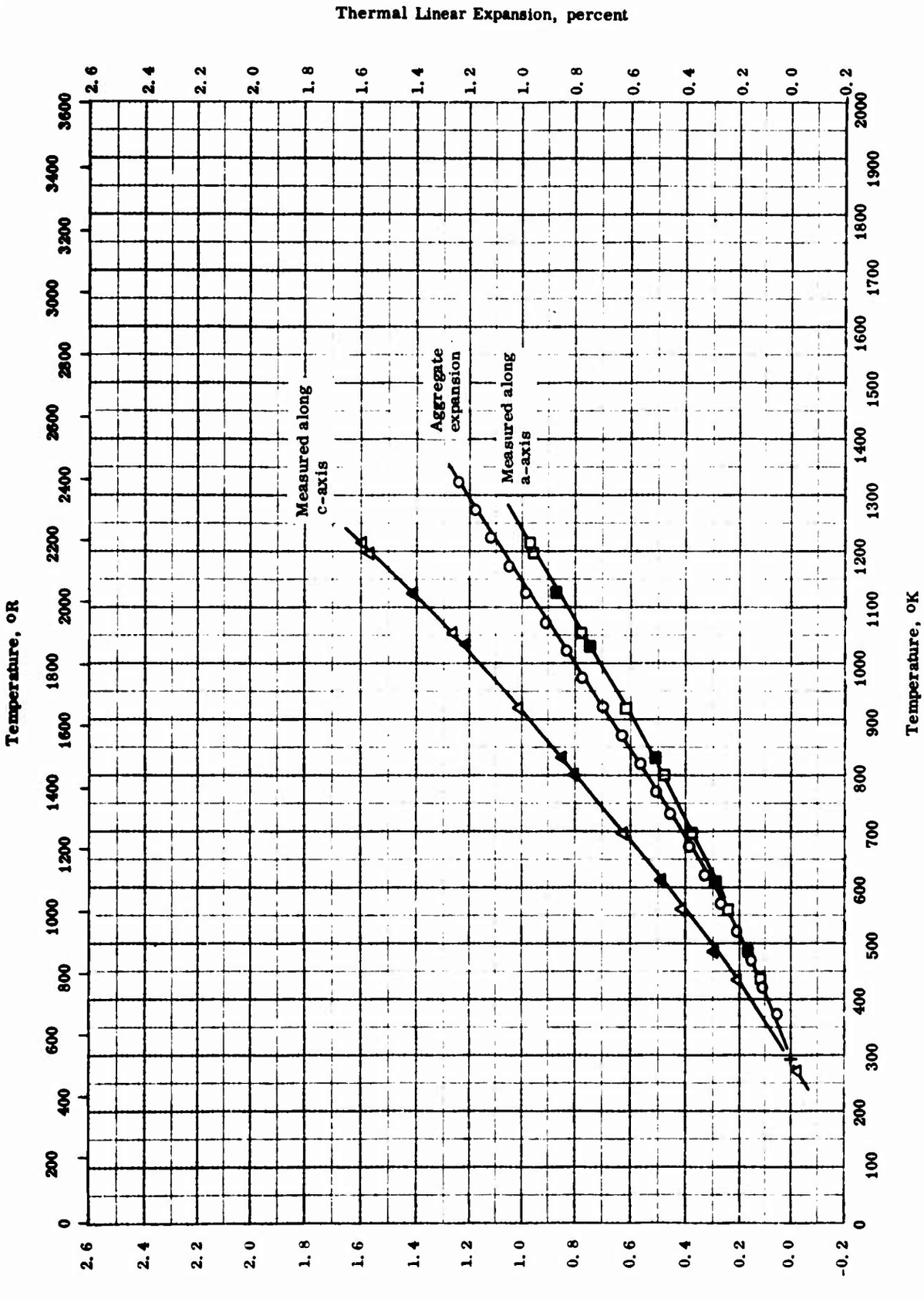
SPECIFIC HEAT -- LANTHANUM OXIDE

TPRC

SPECIFIC HEAT -- LANTHANUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	51-7	383-1171	0.4	La_2O_3.	
Δ	61-15	53-1800	0.1	99.997 La_2O_3.	Under vacuum.

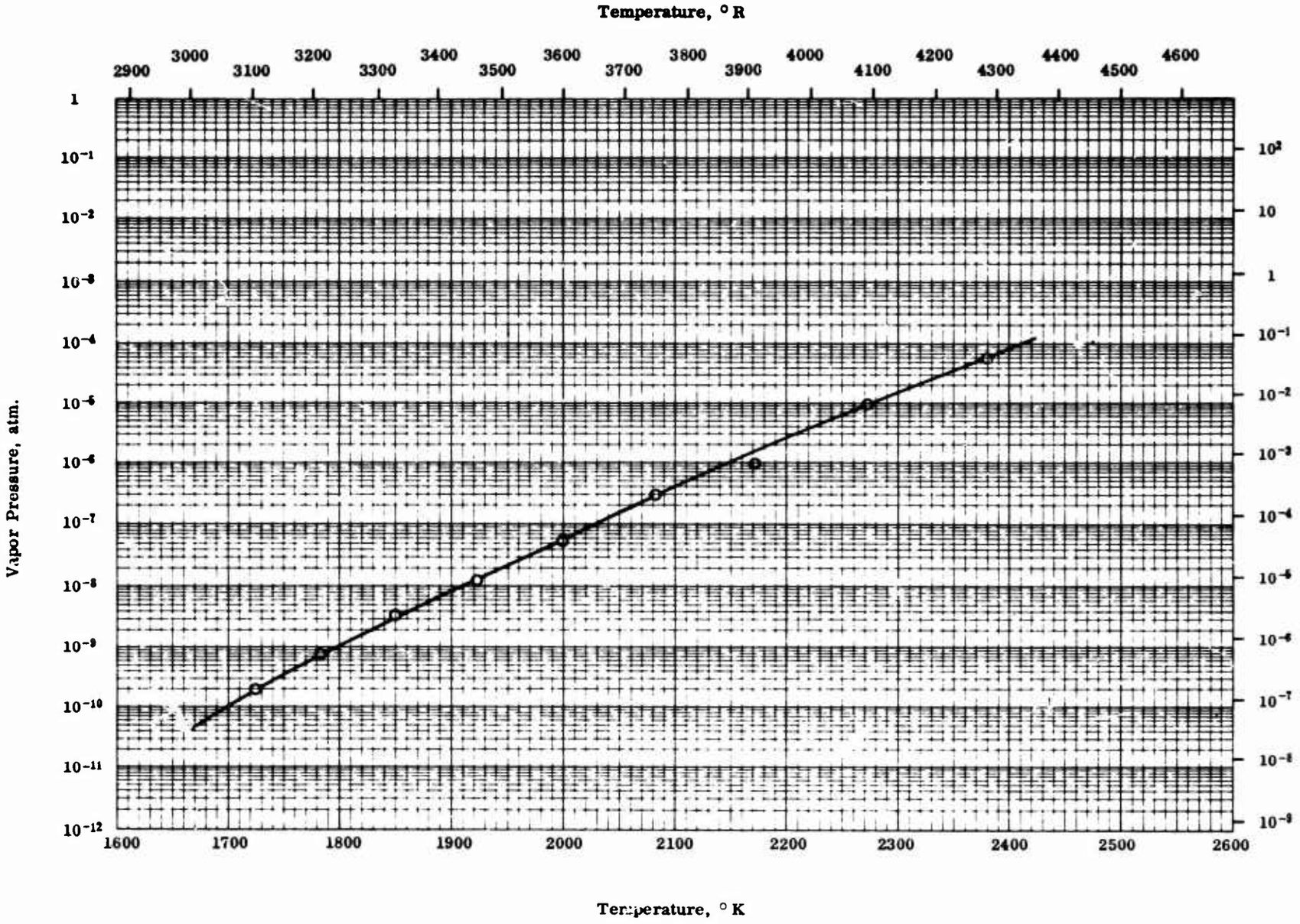


THERMAL LINEAR EXPANSION -- LANTHANUM OXIDE

THERMAL LINEAR EXPANSION -- LANTHANUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	64-26	298-1323		La_2O_3; 0.05 Sm, 0.04 Si, 0.02 Eu, 0.01 Fe, 0.0005 Mg, 0.02 > Dy, and 0.01 > Gd; polycrystal, randomly oriented.	Dry-pressed at 20,000 psi in a double-acting steel die into pellets 1/2 in. in diameter by 2 in. long, sintered at 1450 C for 1 hr in an oxidizing atm, furnace cooled to 200 C, and transferred to a vacuum desiccator to cool to room temperature; temperature control maintained at a rate of 3 to 5 C min^{-1}.
□	61-41	273-1214	1.1-6.0	La_2O_3, code 528 from Lindsay Chemical Co., West Chicago, Ill.; 99.9 La_2O_3 in regard to total rare-earth content; 0.001 - 0.01 Ca, Mg, and Si and trace of Al, Cu, and Fe; hexagonal, rare-earth oxide type A.	Sintered at 1000 C for 24 hrs, cooled rapidly to 500 C, placed in vacuum desiccator until room temperature was reached, packed into alumina sample holder, resintered at 1000 C for 24 hrs, cooled to 750 C, and placed in a vacuum desiccator for storage; measured along a-axis with x-ray diffractometer.
■	61-41	487-1214	1.1-6.0	Same as above.	Cooling cycle for above sample measured along a-axis.
△	61-41	273-1214	1.1-6.0	Same as above.	Same as heating cycle for above sample except measured along c-axis.
▲	61-41	487-1214	1.1-6.0	Same as above.	Cooling cycle for above sample measured along c-axis.



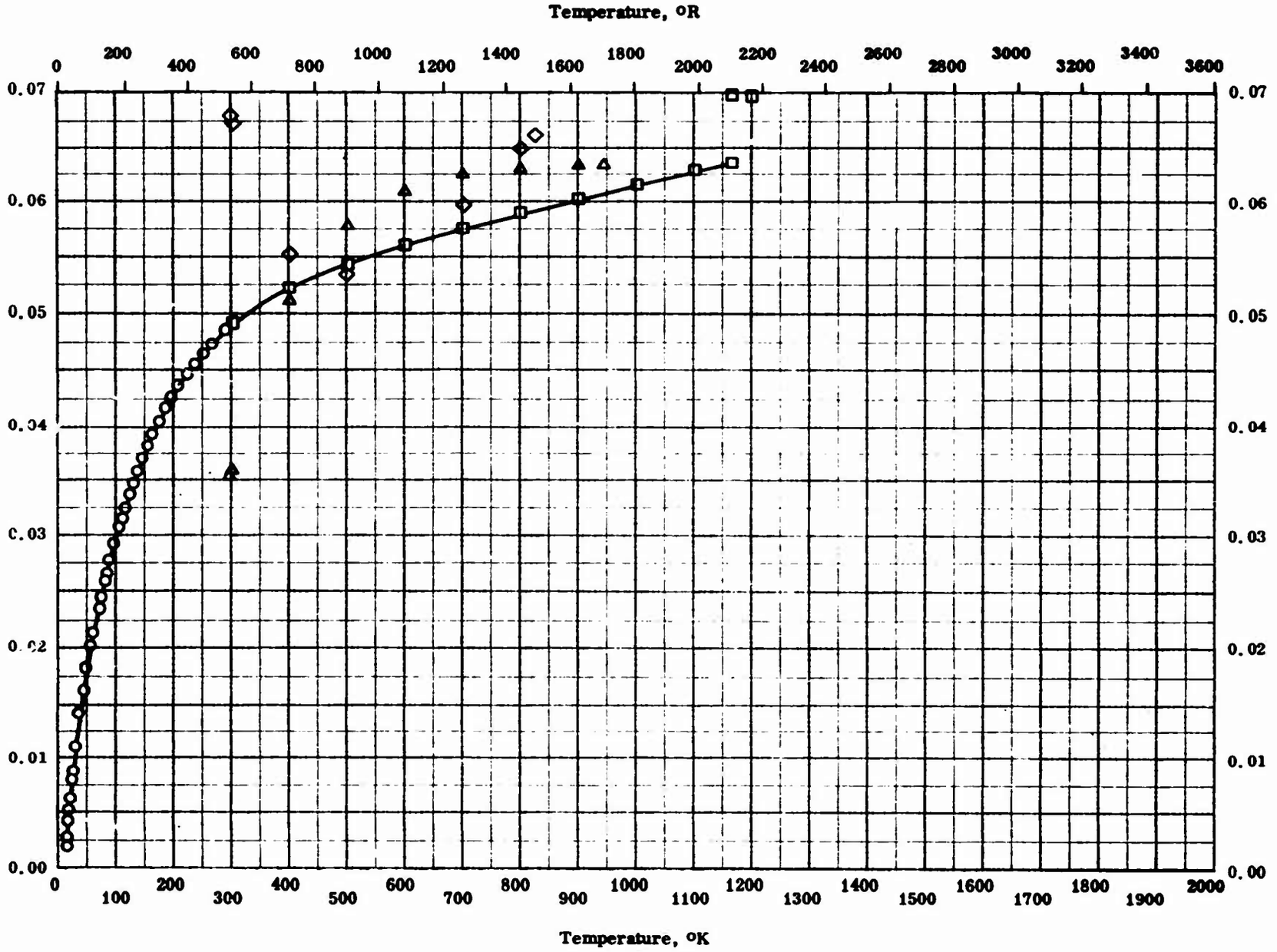
VAPOR PRESSURE -- LANTHANUM OXIDE

TPRC

VAPOR PRESSURE -- LANTHANUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-9	1724-2381		La_2O_3.	Vapor press. for reaction $La_2O_3 \rightarrow LaO + O_2$; below 3400 R author quote data of others.



SPECIFIC HEAT -- LEAD MONOXIDE

SPECIFIC HEAT -- LEAD MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specification	Remarks
□	61-18	300-1200	0.01	Yellow PbO.	
○	60-10	12-303		99.5 PbO; crystalline; yellow color.	Dried at 150 C under 0.05 mm Hg; measured under 20 mm Hg helium atm.
△	42-3	298-943		Yellow lead monoxide.	Prepared by heating red monoxide at 600 C for 3 hrs.
◇	42-3	298-823		Red lead monoxide.	Dried in vacuum desicator with potassium hydroxide and later for two weeks with anhydrous magnesium perchlorate; heated at 140 C and later at 400 C.

PROPERTIES OF LITHIUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	2.013	125.5
Melting Point	1973*	3551*
Heat of Fusion	468.5	843.3
Heat of Vaporization. . . .	4697	8455
Heat of Sublimation	3517	6331

*Handbook of Chemistry and Physics (Ref. 64-16)

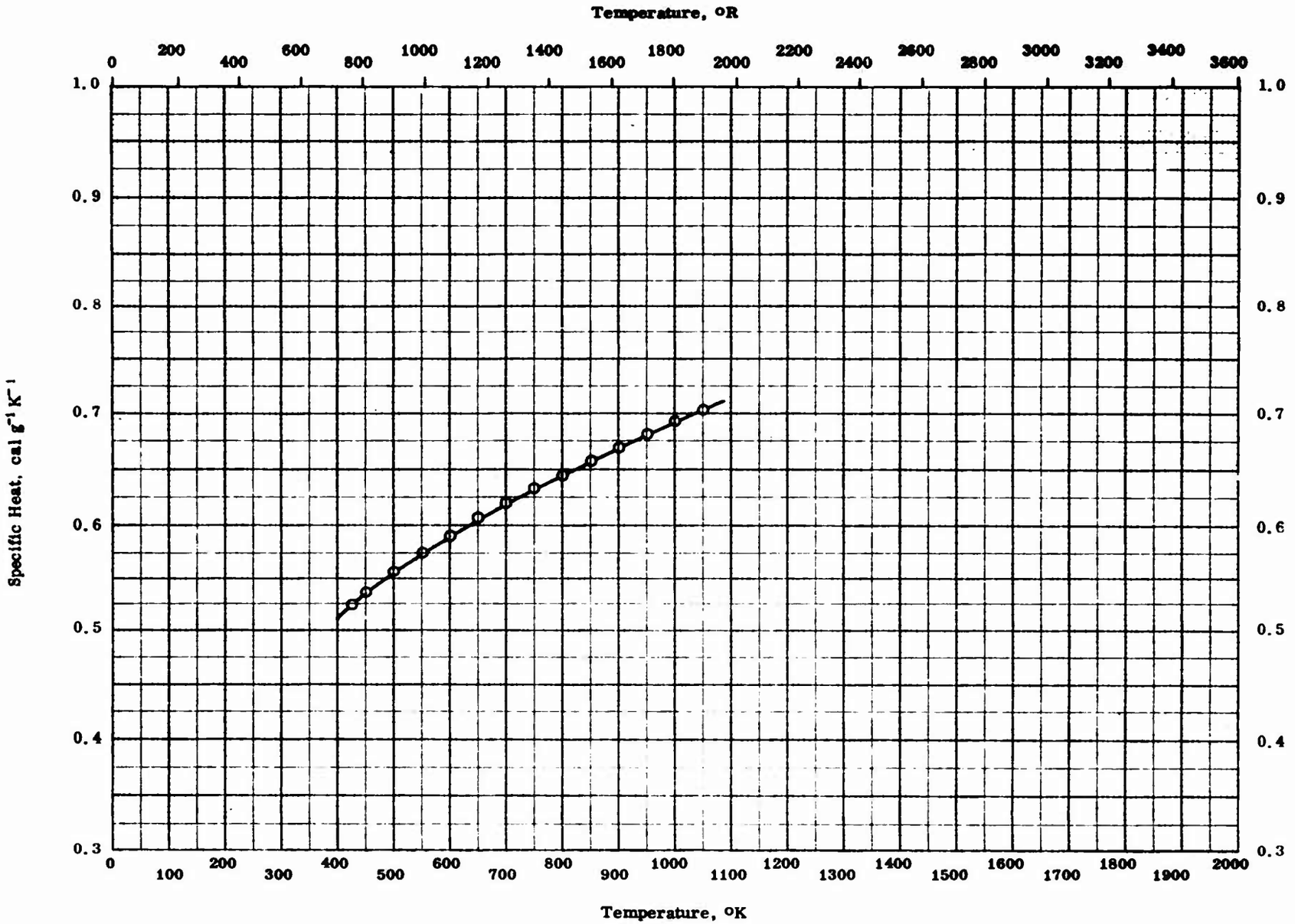
REPORTED VALUES

Density		g cm^{-3}	lb ft^{-3}
		2.013	125.5
Heat of Fusion		cal g^{-1}	Btu lb^{-1}
	△	468.5	843.3
Heat of Vaporization		cal g^{-1}	Btu lb^{-1}
	▽	4697	8455
Heat of Sublimation		cal g^{-1}	Btu lb^{-1}
	□	3517	6331

PROPERTIES OF LITHIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-25	298		Li_2O.	
△	61-25	298		Li_2O.	
▽	61-25	298		Li_2O.	
□	63-11	298		Li_2O.	

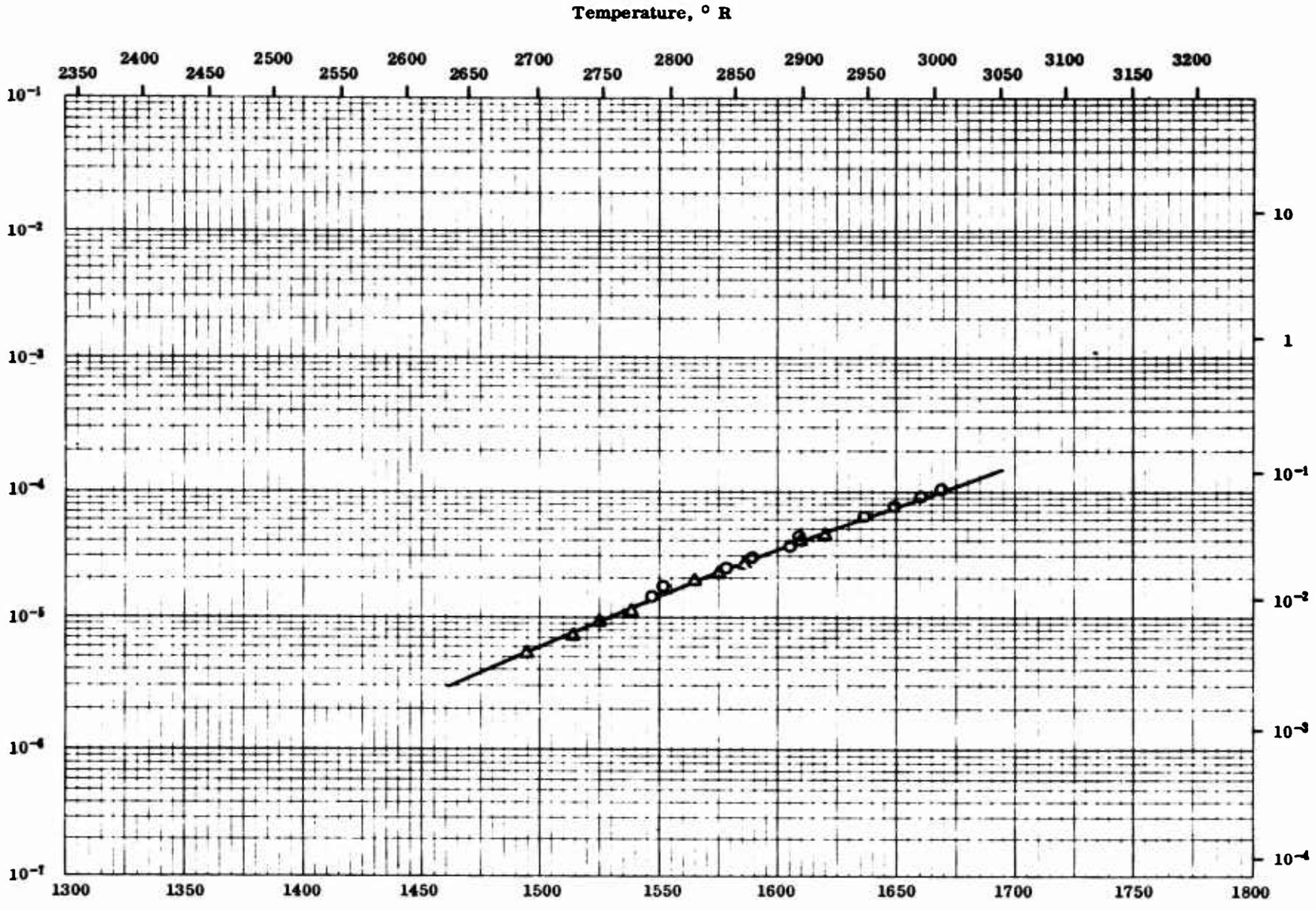


SPECIFIC HEAT -- LITHIUM OXIDE

SPECIFIC HEAT -- LITHIUM OXIDE

REFERENCE INFORMATION

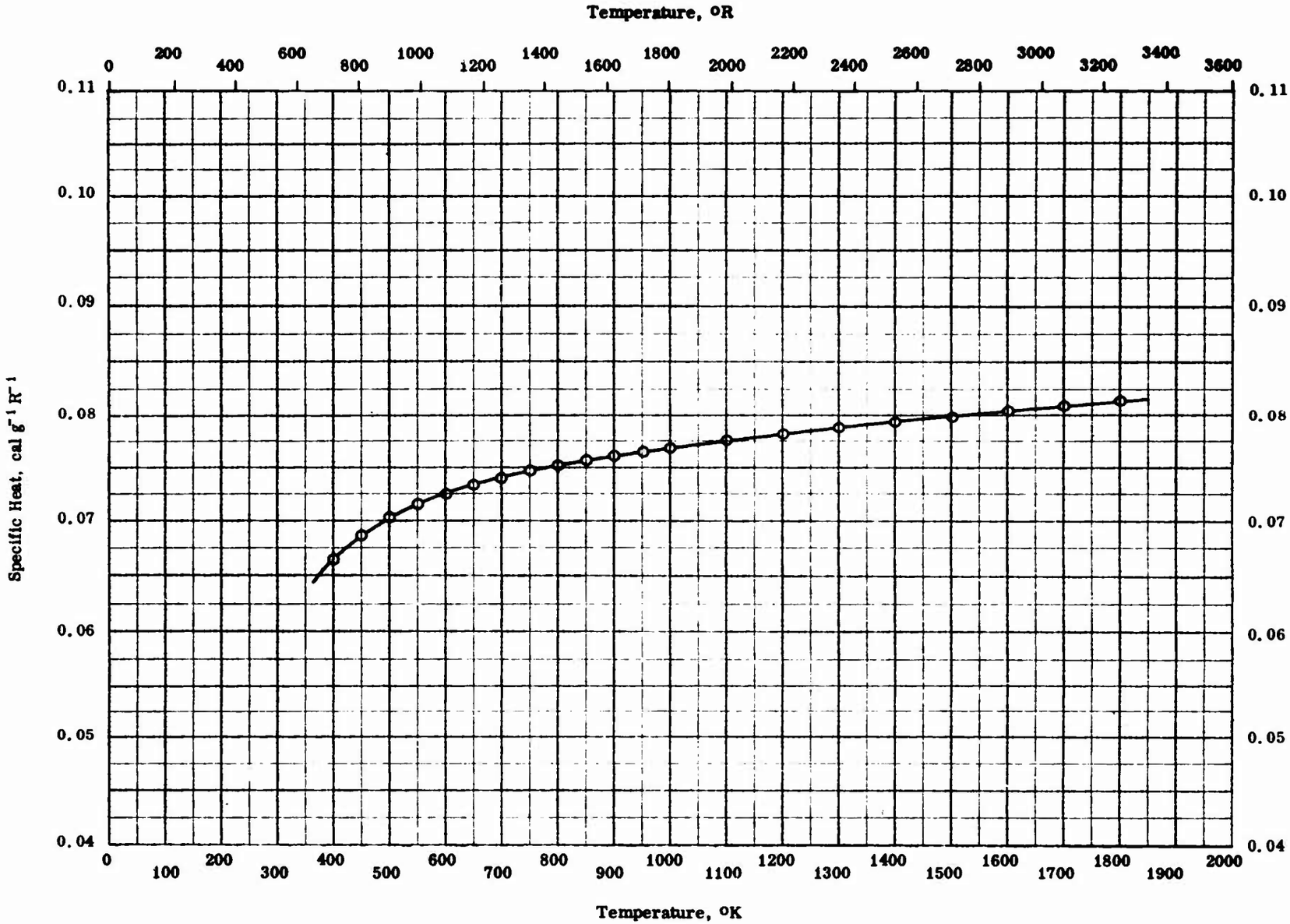
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	55-15	425-1045		99.2 Li_2O and 0.8 LiOH; prepared from 99.9 Li_2O_3.	



VAPOR PRESSURE -- LITHIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-11	1547-1669		Li_2O.	Prepared from thermal decomposing reagent grade lithium carbonate by heating gradually to 1000 C in platinum crucible under vacuum; data reported are total pressure including partial pressures of Li_2O (about 60 mole %), O_2(g) and Li(g).
Δ	63-11	1494-1615		Same as above.	Same as above.

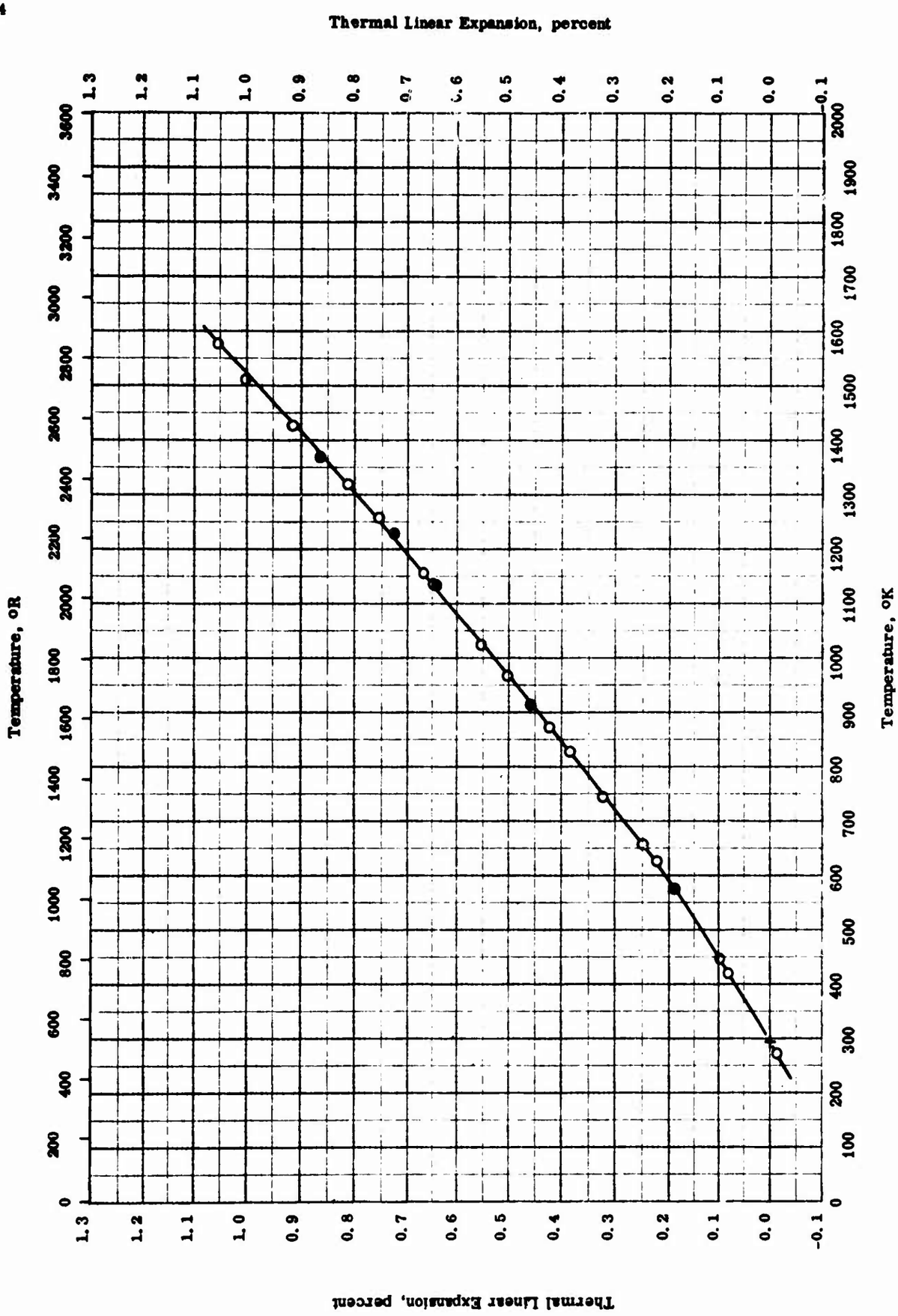


SPECIFIC HEAT -- LUTETIUM OXIDE

SPECIFIC HEAT -- LUTETIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-15	400-1800		99.9 Lu_2O_3.	Dried at 1100-1200 C.

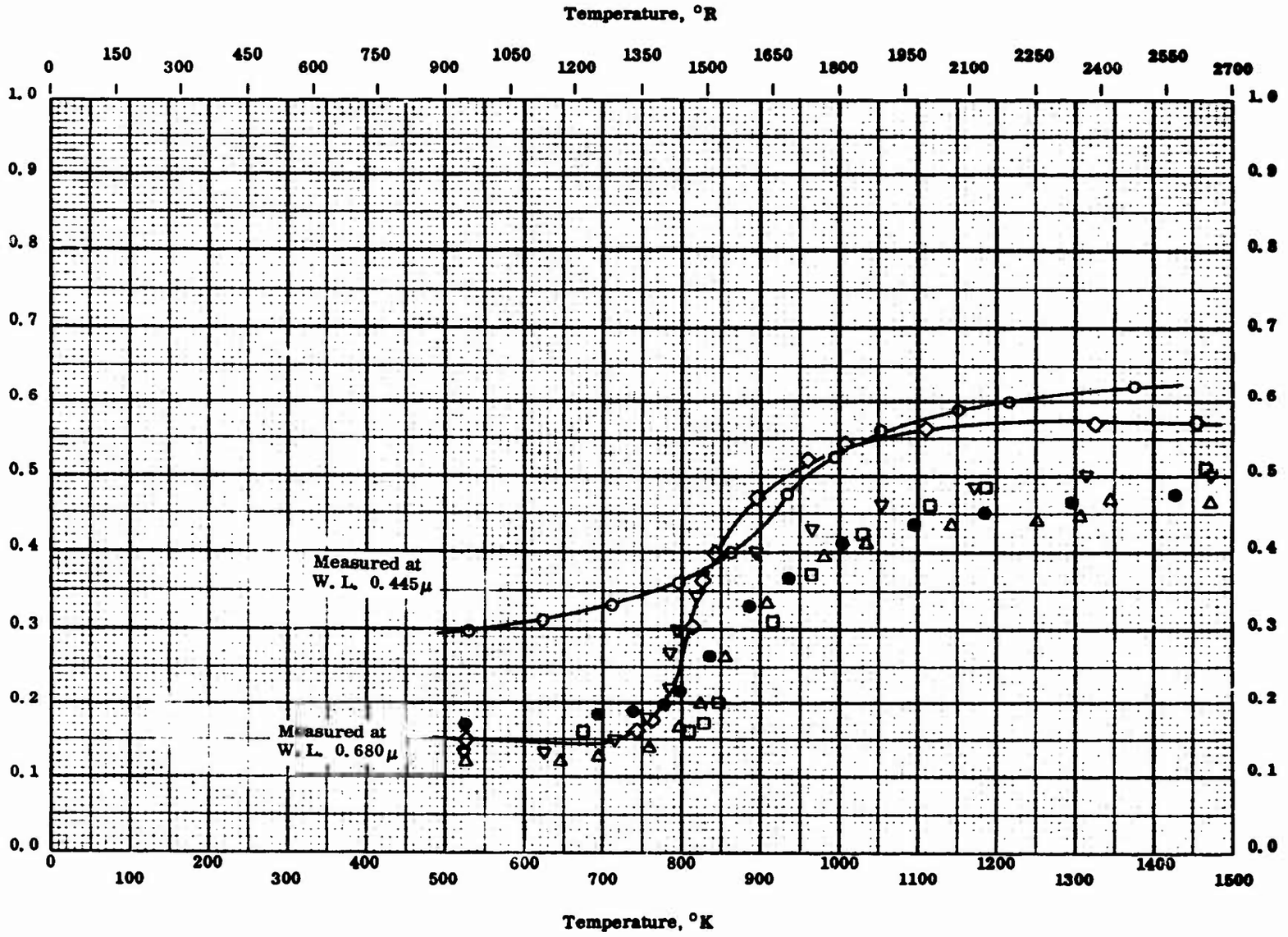


THERMAL LINEAR EXPANSION -- LUTETIUM OXIDE

THERMAL LINEAR EXPANSION -- LUTETIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-41	273-1573	1.1-6.0	Lu_2O_3, code 1505 from Lindsay Chemical Co., West Chicago, Ill.; 99.9 Lu_2O_3 in regard to total rare-earth content; 0.03 - 0.3 Sm, 0.01 - 0.1 Eu, 0.003 - 0.03 Ca, 0.001 - 0.01 Al, B, and trace of Cu, Mg, Mn, and Si; cubic, rare-earth oxide type C.	Sintered at 1200 C for 24 hrs, packed into alumina sample holder, resintered at 1250 C for 12 hrs, cooled to 300 C, and placed in a vacuum desiccator for storage; x-ray diffractometer method.
●	61-41	578-1573	1.1-6.0	Same as above.	Cooling cycle for above sample.



NORMAL SPECTRAL EMITTANCE -- LUTETIUM OXIDE

NORMAL SPECTRAL EMITTANCE -- LUTETIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Wavelength μ	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	63-25	0.445	528-1373		Lu_2O_3.	Powdered material compressed to 75000 psi, fired at 1773 K for 24 hrs; ground to 0.125 in. thickness; measured in air; data taken from smooth curve; calculated from reflectance data.
●	63-25	0.488	523-1428		Same as above.	Same as above.
△	63-25	0.533	523-1471		Same as above.	Same as above.
▽	63-25	0.570	523-1473		Same as above.	Same as above.
□	63-25	0.605	523-1468		Same as above.	Same as above.
◇	63-25	0.680	523-1453		Same as above.	Same as above.

PROPERTIES OF MAGNESIUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density	3.77	235
Melting Point	3223	5802

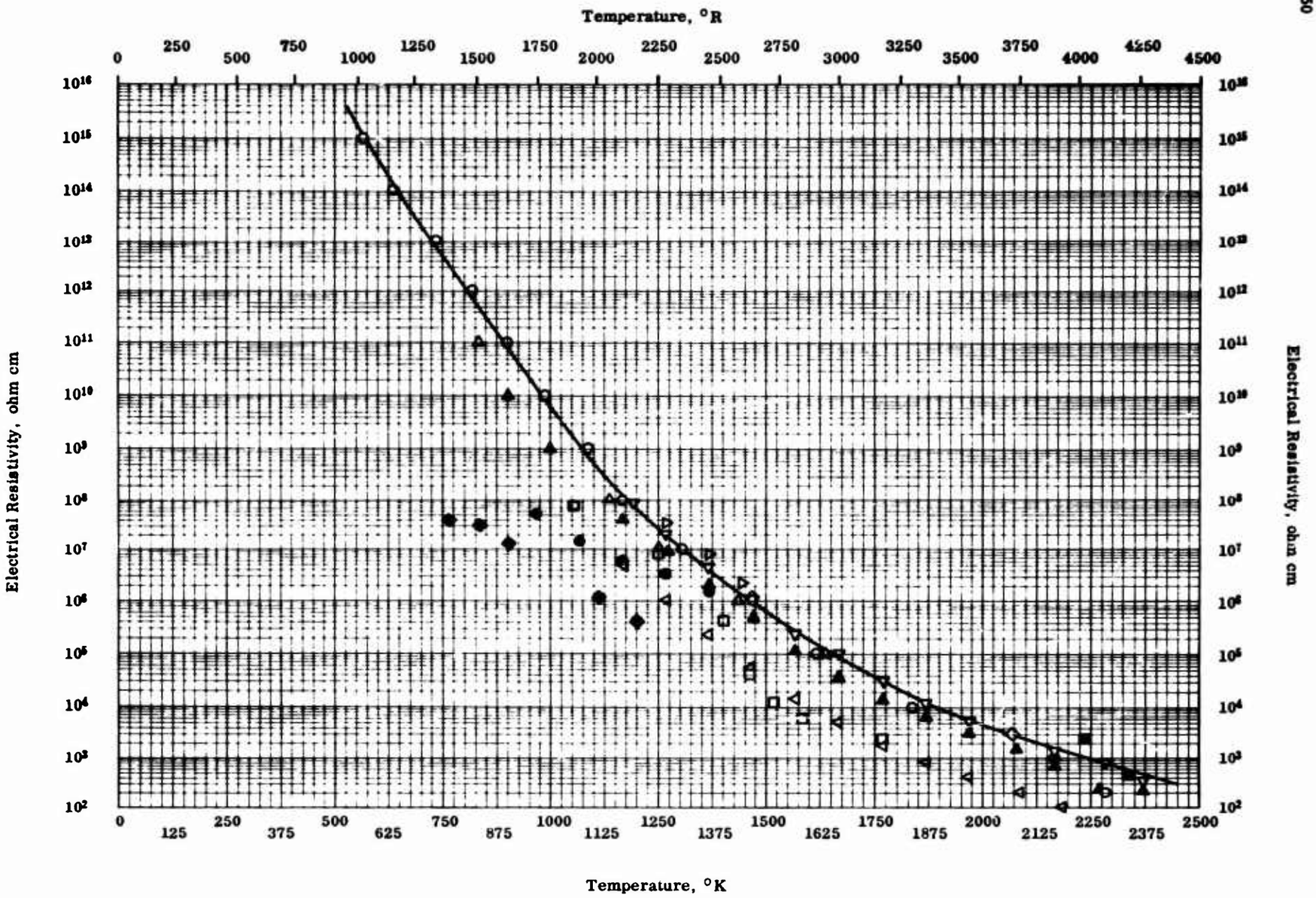
REPORTED VALUES

		$g\,cm^{-3}$	$lb\,ft^{-2}$
Density			
	○	3.6	225
	◁	3.39	212
	◇	3.77	235
	▽	2.04	127
	▷	3.4	212
		K	R
Melting Points			
	□	3223	5802
	△	3073	5532

PROPERTIES OF MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	60-22	298		MgO	
◁	50-9	298		60.02 Mg, 39.58 O_2, 0.07 combined C, and 0.01 > free C.	Hot-pressed; author quoted theoretical density 3.62 g cm^{-3}; density by weight in air and in distilled water.
□	51-15	3223		MgO	M. P. by visual observation
△	49-3	3073		MgO	
◇	50-11	298		MgO; from $Mg(OH)_2$ containing 1.0 each Al, Ca, Na, 0.01<each Fe, B, K, and 0.01 >each Cu and Si.	Calcined 1 hr at 1000 C and pressed at 52000 psi; density computed from x-ray measurement.
▽	50-11	298		Same as above.	Same as above.
▷	50-11	298		Same as above.	Same as above, but also fired at 1900 C.

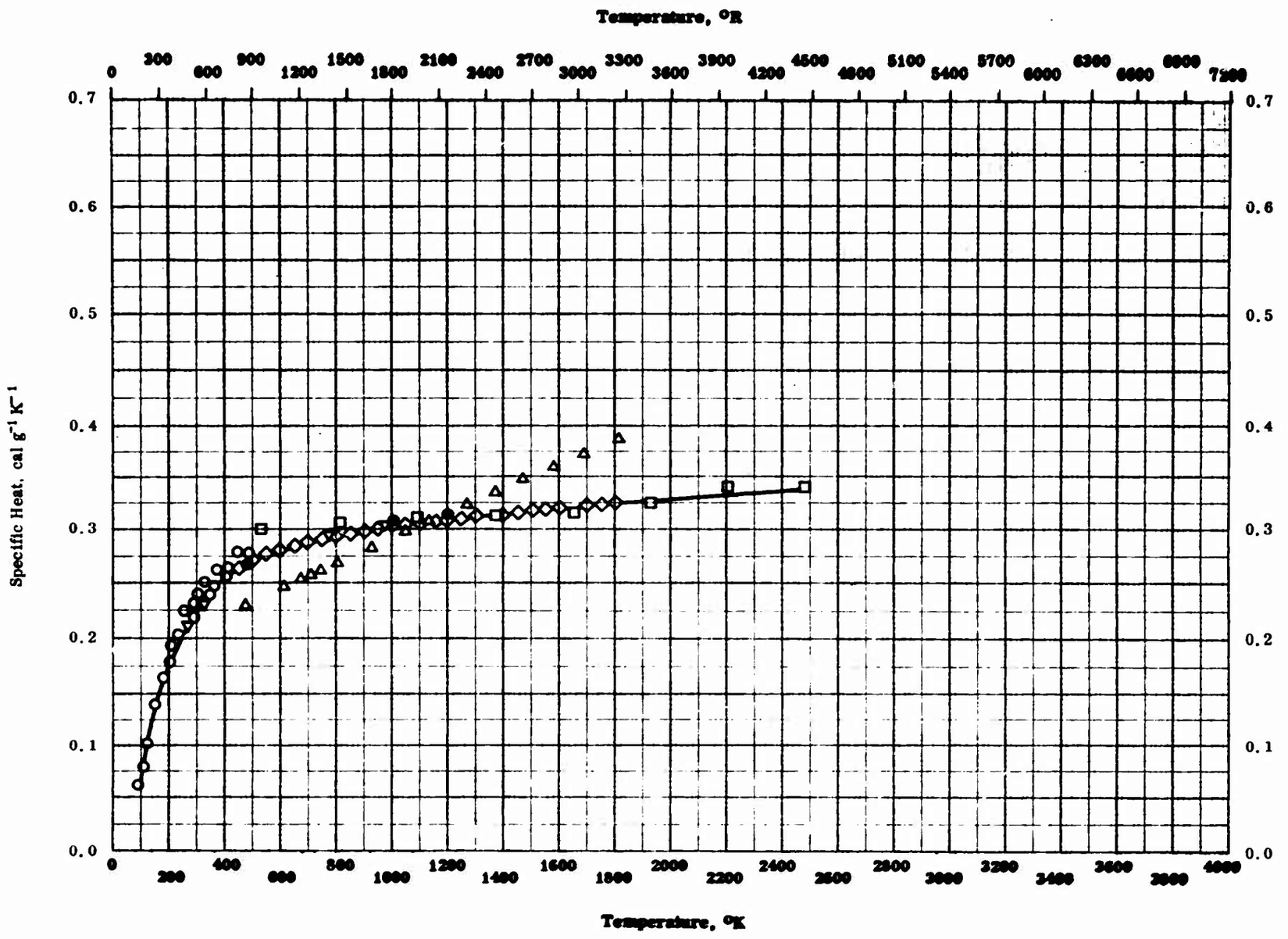


ELECTRICAL RESISTIVITY -- MAGNESIUM OXIDE

ELECTRICAL RESISTIVITY -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-20	573-2273		Very pure.	Prepared by burning 99.99 pure Mg in purified O_2; powder mixed with conductivity water and sintered in high vacuum.
□	53-17	1053-1773		100 MgO, c.p. grade.	Calcined at 1000 C and fired 10 hrs to 1500 C.
△	53-19	833-1667		MgO; density 70% greater than calculated from X-ray measurement.	Sintered 14 hrs at 1500 C.
◇	49-3	1473-2073		MgO.	
▽	42-4	973-2373		Pure; density 174 lb ft^{-3}.	Compressed at 430 psi and calcined at 2100 C.
▷	42-4	973-2373		Pure; density 62 lb ft^{-3}.	Compressed at 430 psi and calcined at 120[illegible] C.
●	42-4	973-2373		Pure; density 62 lb ft^{-3}.	Hydrated; compressed at 430 psi.
▲	42-4	973-2373		Pure; density 234 lb ft^{-3}.	Cast.
◁	42-4	973-2373		97.5 MgO and 2 SiO_2; density 233 lb ft^{-3}.	Cast industrial grade.
◆	56-13	772-1206		MgO; polycrystalline; prepared from chemically pure materials.	Calcined for 2 hrs.
■	62-4	2239-2339	2.4	MgO; 59.4 Mg.	Pressed and sintered; max. exposure temperature 4450 F

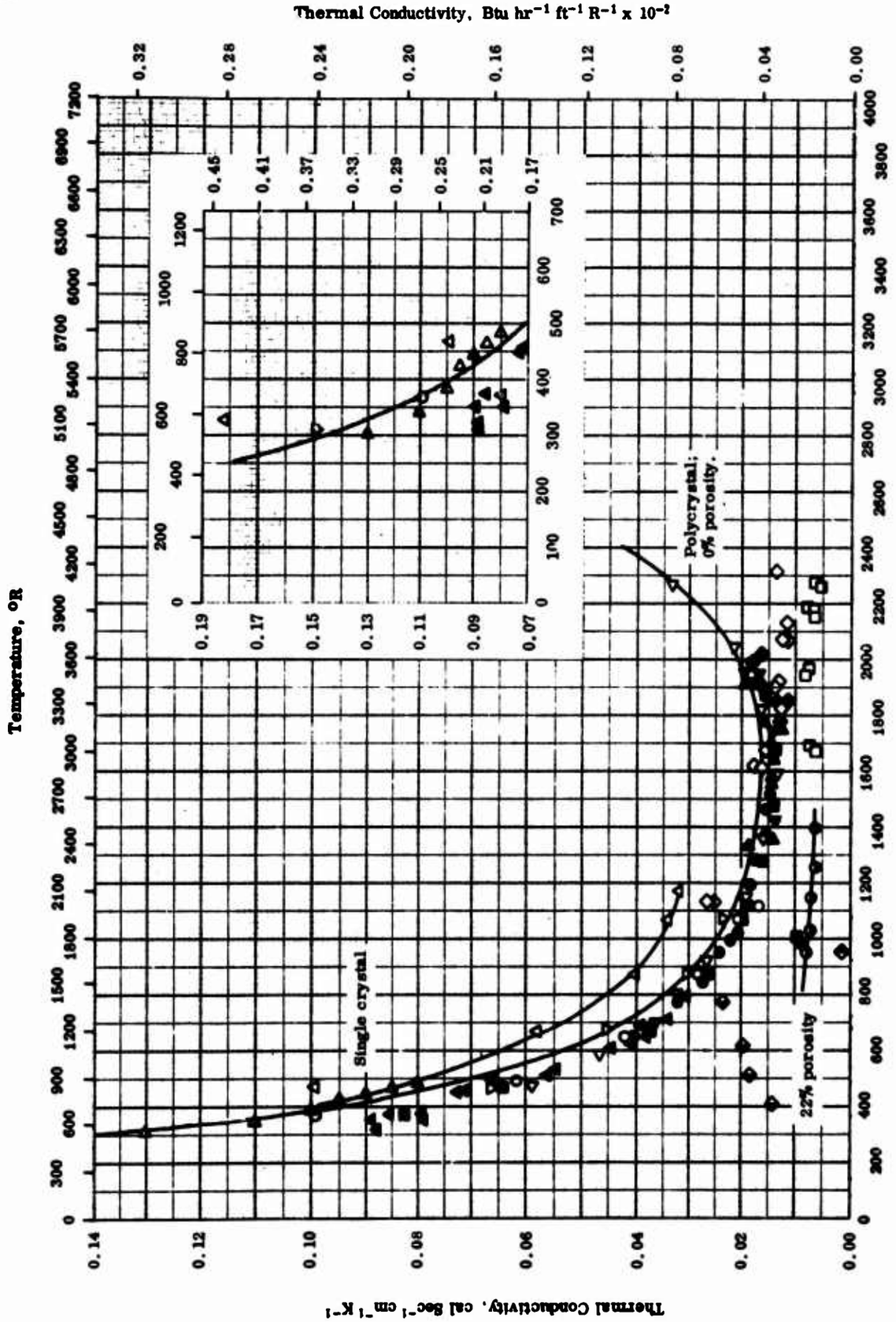


SPECIFIC HEAT -- MAGNESIUM OXIDE

SPECIFIC HEAT -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-2	90-481	≤5.0	MgO.	Hanova liquid platinum applied on specimen's front surface for opaqueness and then painted with Parson's black for constant absorptivity; hanova liquid platinum coatings applied also on specimens rear surface to obtain good conductive surface.
□	62-4	533-2478	≤5.0	Before test: 59.4 Mg, 0.3 Fe, 0.3 Si, 0.2 Ca, 0.1 Al; density 219 lb ft^{-3}; and after test: 60.1 Mg, 0.05> C; density 224 lb ft^{-3}.	Crushed in hardened steel mortar to pass 100-mesh screen; pressed and sintered.
△	61-6	475-1811	3.0	99.0< MgO, 0.5> Si, and 0.3> Mn; density 186 lb ft^{-3}.	Under helium atm.
◇	63-14	298-1800	0.1	99.93 MgO, 0.04 Al_2O_3, and 0.01 SiO_2; macrocrystalline.	
▽	40-2	273-1173	0.25	0.025 Ca, 0.020 Fe, 0.009 Si, 0.008 Mn, 0.004 Al, 0.002>Na, 0.001>Ag, 0.001>Cr, and 0.001>Cu; single crystal.	
●	63-18	298-1200	0.4	99.90 MgO, 0.025 Ca, 0.02 Fe, 0.009 Si, 0.008 Mn, 0.004 Al, 0.002> Na, 0.001>Ag, 0.001>Cr, and 0.001>Cu.	Fused.



THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◁	61-6	478-2264	< 5	99 < MgO, 0.5 > Si, and 0.3 > Mn.	Sample contained 5 one-inch disks.
▷	62-2	303-483	± 5	Single crystal.	
◇	62-4	1133-2322	5-7		Ground and polished thoroughly; sample found broken and partially melted on post inspection.
□	62-4	1663-2269	5-7		Same as above except a larger sample; sample found cracked and color changed on post inspection.
△	57-4	273-1273		Single crystal.	
▽	57-4	273-1273		Polycrystal; average crystal size 8μ; porosity 4.75%.	Data corrected to zero porosity.
○	57-4	273-1273		Polycrystal; average crystal size 12μ; porosity 13.7%.	Data corrected to zero porosity.
◈	58-5	952	± 10	Periclase; compressed granular sample with porosity 23.5%.	
◉	58-5	981	± 10	Same as above except porosity 15.2%.	
⊡	58-5	1001	± 10	Same as above except porosity 13.7%.	
■	54-1	373-1873		Polycrystal; bulk density 3.29 - 3.48 g cm^{-3} and porosity 2.8 - 8.1%.	
●	53-6	653-1513	< 5	Total porosity of 8.10 - 8.93% with a bulk density 3.26 - 3.29 g cm^{-3}.	Fired.
▲	53-6	313-893	< 7	Zero apparent porosity with a bulk density of 3.48 g cm^{-3}.	Slip-cast and fired.

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THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE (continued)

REFERENCE INFORMATION

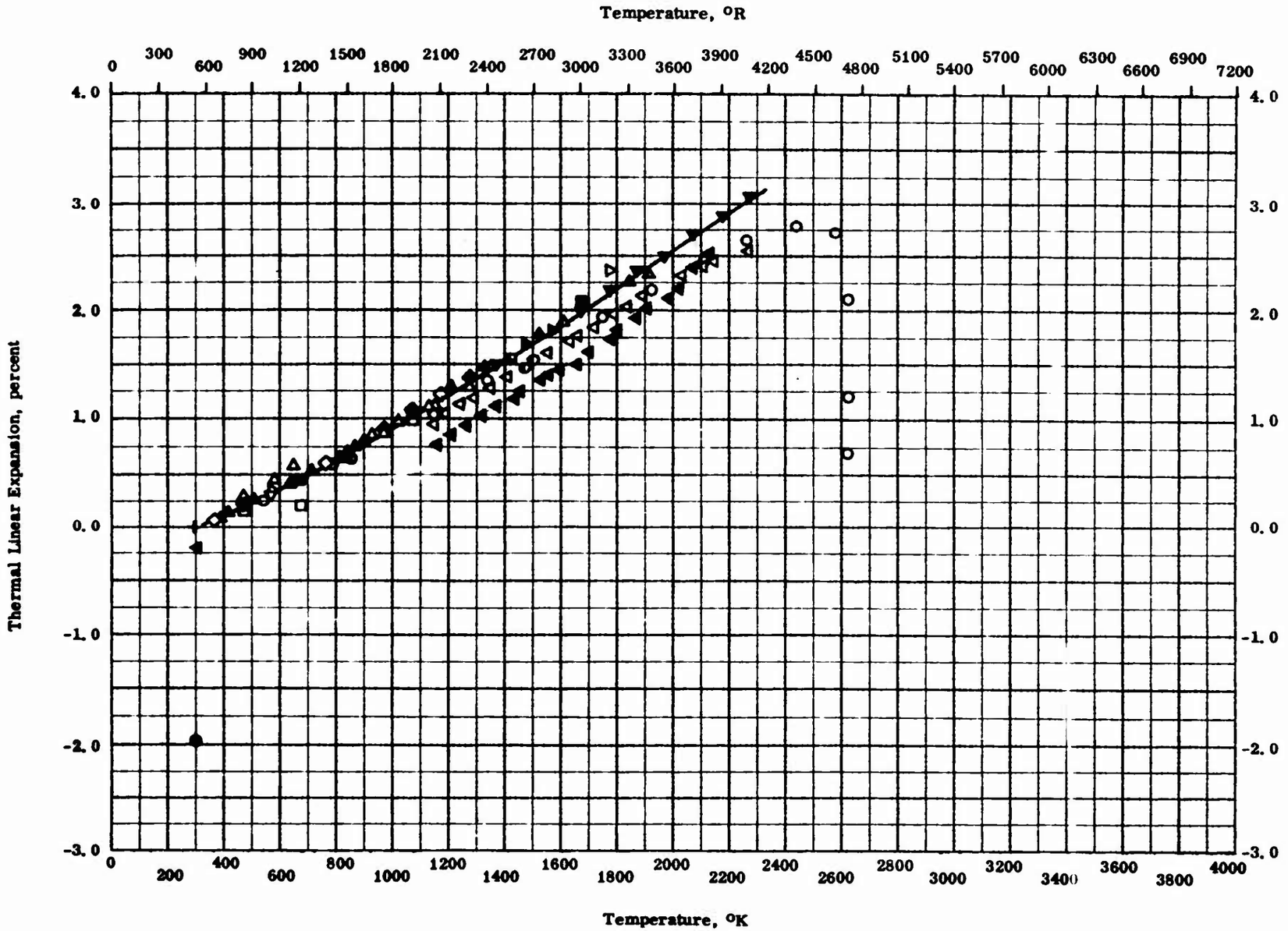
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▶	53-6	1283-1908	< 10.7	0.15 CaO, 0.30 SiO_2, 0.14 Al_2O_3, and 0.05 Fe_2O_3, final total porosity 5-10%. [Author's design.: M-10]	Slip-cast and fired to zero apparent porosity at 1850 C.
◀	53-6	1423-1953	< 10.7	Same as above. [Author's design.: M-11]	Same as above.
◆	53-6	1573-2023	< 10.7	Same as above. [Author's design.: M-12]	Same as above.
⊖	49-1	950-1395		Periclase product made from 6 mesh and finer grain; density 175 lb/ft³, apparent porosity 19% and total porosity 22%.	Fired at 3230 F.
◈	43-1	408-772		Synthetic periclase; isotropic.	

THERMAL DIFFUSIVITY -- MAGNESIUM OXIDE

THERMAL DIFFUSIVITY — MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-2	223-478	<5	Single crystal.	
□	63-2	998-1638	±5-10	SR 2808 Corning magnesium oxide; non-homogeneous; density 3.43 g cm^{-3}.	
△	63-2	988-1643	±5-10	PC-235 Corning magnesium oxide; non-homogeneous; density 3.39 g cm^{-3}.	
▽	62-1	298-1273	15	Density 3.30 g cm^{-3}.	
▷	50-1	673-823		True density 3.5 g cm^{-3}; open pores 12% and total pores 14%.	Cast from alcoholic suspensions of finely ground recrystalized magnesia and fired at 1800 C for 5 hrs.
◁	50-1	673-1023		Same as above	Same as above



THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE

THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-4	294-2611	5	MgO from Zirconium Corp. of America; 59.4 Mg; elements found by semi-quantitative emission spectrography before exposure 0.3 Fe, 0.3 Si, 0.2 Ca, and 0.1 Al; after exposure 60.1 Mg and < 0.05 C; density in g cm^{-3} at 25 C by ASTM method B311-58 before exposure 3.30, after exposure 3.50; initial length 2.953 in., final length 2.887 in. [Author's design : Run No. E 13]	Pressed and sintered; measured in helium atm; incipient melting evident on post inspection.
●	62-4	294-2611	5	Same as above.	Cooling cycle for above sample.
□	63-34	293-1273		Fabricated from Baker's AR grade MgO; translucent oxide; >98% theoretical density; dimensions 2 in. in diameter by 1/4 in. thick.	Hot pressed with pressure initially applied at 900 C, increased gradually to final pressure of 6000 psi and temperature of 1400 C, held at final pressure 4 hrs, and cooled overnight; measured in air atm.
◇	63-35	298-1274		MgO prepared from commercial single-crystal rods.	Matured at 1000 C for 1 hr and desiccated; measured with heating rate of approx. 5 C min^{-1}.
◆	63-35	298-1272		Same as above.	Second run for above sample.
△	64-27	298-1275		MgO.	X-ray diffraction method.

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REFERENCE INFORMATION

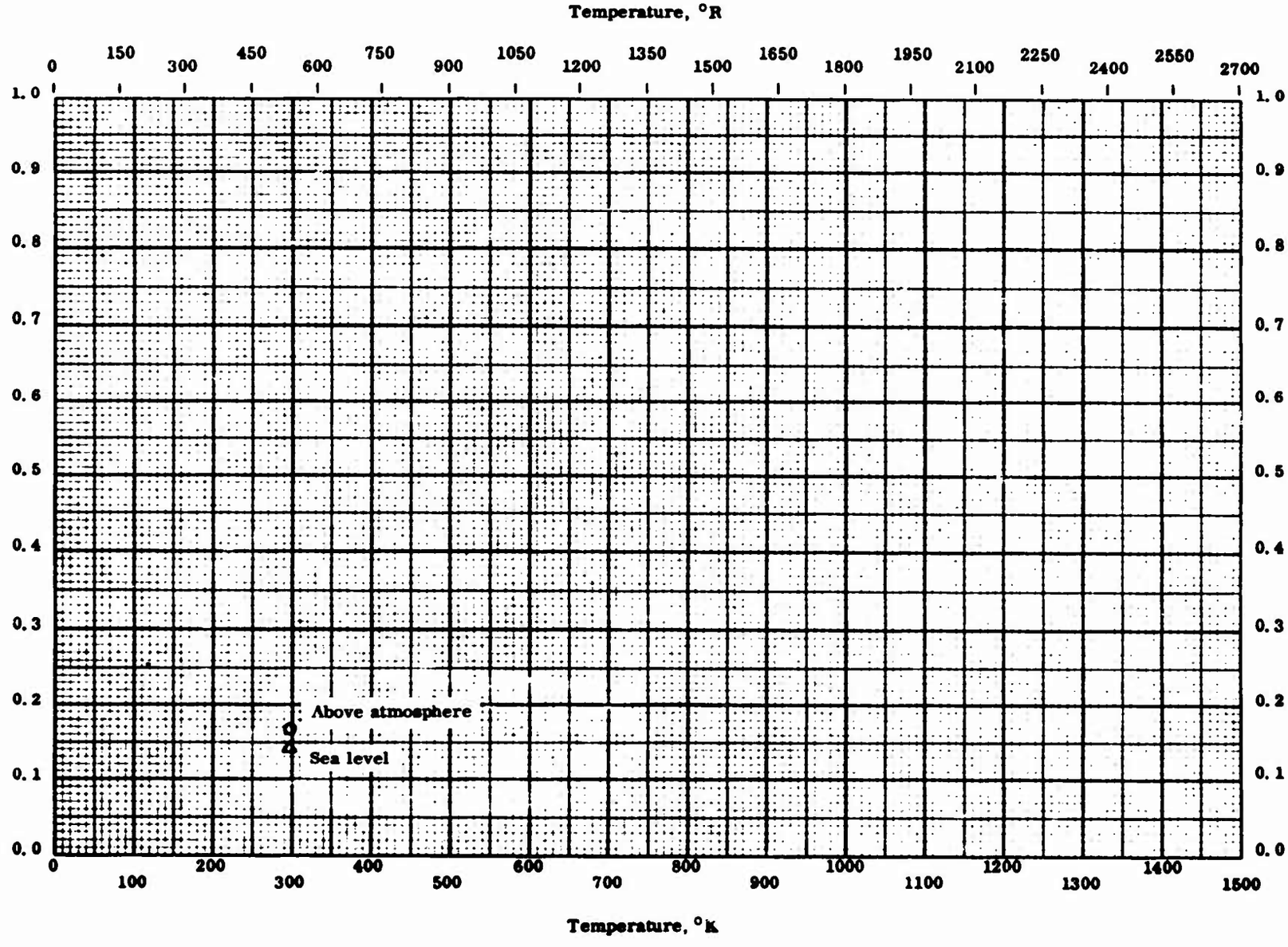
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▲	64-27	298-1205		MgO; 0.3 Ca, 0.03 Si, 0.02 each Ti, Mn, and Fe, 0.01 B, 0.005 Cr, 0.003 Zn, 0.002 Al, 0.001 each K, V, Ni, Cu, Sr, Cd, Sn, Ba, and Pb, and trace of Na, Bi, Co, Mo, Li, Be, and Ag; Au impurities: 0.1 each Rn, Rh, and Ir, 0.04 each K, V, Co, Cd, and Pb, 0.02 Sr, 0.01 each Na, Al, Ca, Cr, Fe, Ni, Pd, Ba, and Pt, 0.001 - 0.1 Si, 0.004 B and Mn, 0.002 Li, and 0.001 each Be, Mg, Cu, and Ag.	Powdered -325 mesh MgO (about 60%) and 40 Au powder sifted into a 10 mil diameter silica capillary with wall thickness 2 mil; MgO fired at 1400 C; Au annealed in vacuo to 300 C and cooled slowly; x-ray diffraction method with internal Au standard calibrated with Pt/Au thermocouple junction in x-ray beam.
▽	65-3	298-1205		Fisher Scientific's M-300 MgO prepared by Norton Chemical Co; 0.1 - 1.0 Ca, 0.01 - 0.1 Fe, 0.003 - 0.03 each Al, Mn, Mo, Na, and Si, and 0.001 - 0.01 B and Ti.	Percent expansion calculated from lattice parameters measured with x-ray camera in vacuo in the range 1×10^{-3} to 5×10^{-3} mm Hg; standard deviation in lattice parameters 15.5×10^{-5} Å; parameters not corrected for refraction.
▼	63-36	293-2273		99.0 MgO+ CaO; prepared from commercial magnesia; dimensions 4 by 4 by 20 mm; bulk density 3.40 g cm^{-3}; apparent porosity 0.0%. [Author's design : Body 14]	Pressed at 1000 Kg cm^{-2} and fired at 1950 C; rate of temperature rise 5 - 8 C min^{-1}; measured in vacuum furnace; authors reported average coefficients.
◁	58-20	297-2265		MgO; density 3.22 g cm^{-3}. [Author's design : Sample No. CJ-6]	Cold pressed and sintered in oxidizing atm at 1750 C; measured in argon atm; sample began to sinter at 1700 C during run.
◀	58-20	303-2265		Same as above.	Cooling cycle for above sample.

(Continued onto next page)

THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE (continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▷	56-28	573-1773		Coarse fused grain MgO.	
■	56-23	293-1673		MgO; single crystal.	
▶	52-21	298-1573		MgO; made from fused refractory grains (< 1% impurities).	Slip cast, dried, fired at 1150 C, machined, and matured 3 hrs at 1830 C.
◐	46-7	293-1473		97.5 electrically fused MgO and 2.5 sea water MgO; porosity when fired to 1450 C 31% and density 151 lb ft^{-3}; porosity when fired to 2100 C 19% and density 177 lb ft^{-3}.	Fired; measured with heating rate of 4 C min^{-1}.
◪	56-30	293-1423		MgO.	Dead burned magnesite ($MgCO_3$).
▲	61-6	294-1908		>99 MgO, 0.5> Si and 0.3> Mn; density 2.98 g cm^{-3}.	

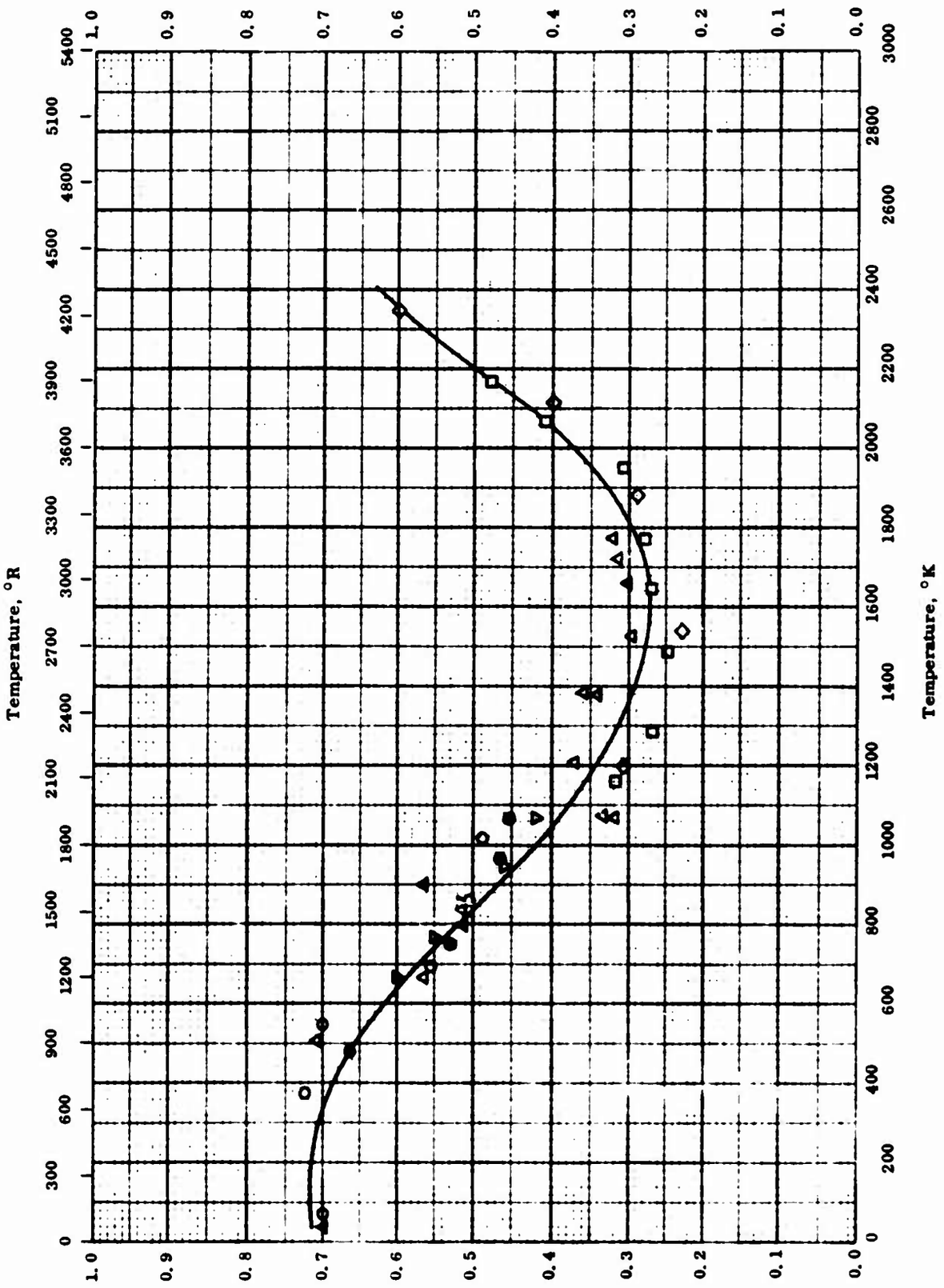


SOLAR ABSORPTANCE -- MAGNESIUM OXIDE

SOLAR ABSORPTANCE -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-27	298		MgO.	Above atmosphere.
Δ	57-27	298		MgO.	Sea level.

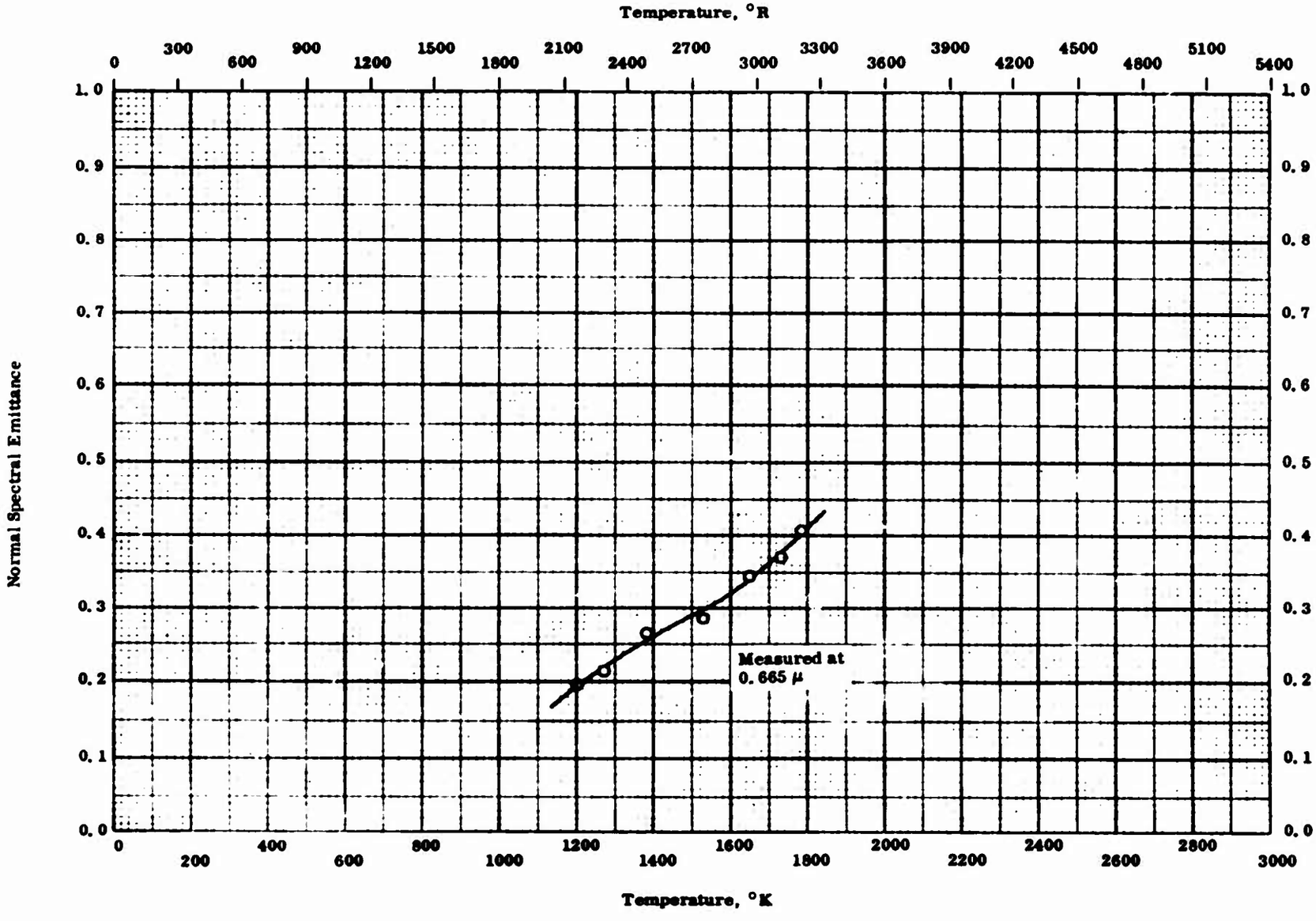


NORMAL TOTAL EMITTANCE -- MAGNESIUM OXIDE

NORMAL TOTAL EMITTANCE -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	58-17	75-1019		MgO.	As received; measured in air in increasing temperature.
●	58-17	478-1061		MgO.	Same as above; cycle 2 in increasing temperature.
△	59-15	44-1778		MgO.	Fused material; measured in air.
▽	52-17	673-1073		MgO powder coating on oxidized Niomonic 75 strip; prepared from super pure magnesium.	Heated in air; data corrected for zero thickness of coating.
□	62-4	1167-2170	10	MgO; density 3.51 g cm^{-3}.	Pressed and sintered; measured in dry argon atmosphere.
◇	62-4	1198-2343	10	Same as above.	Same as above; run No. 2.

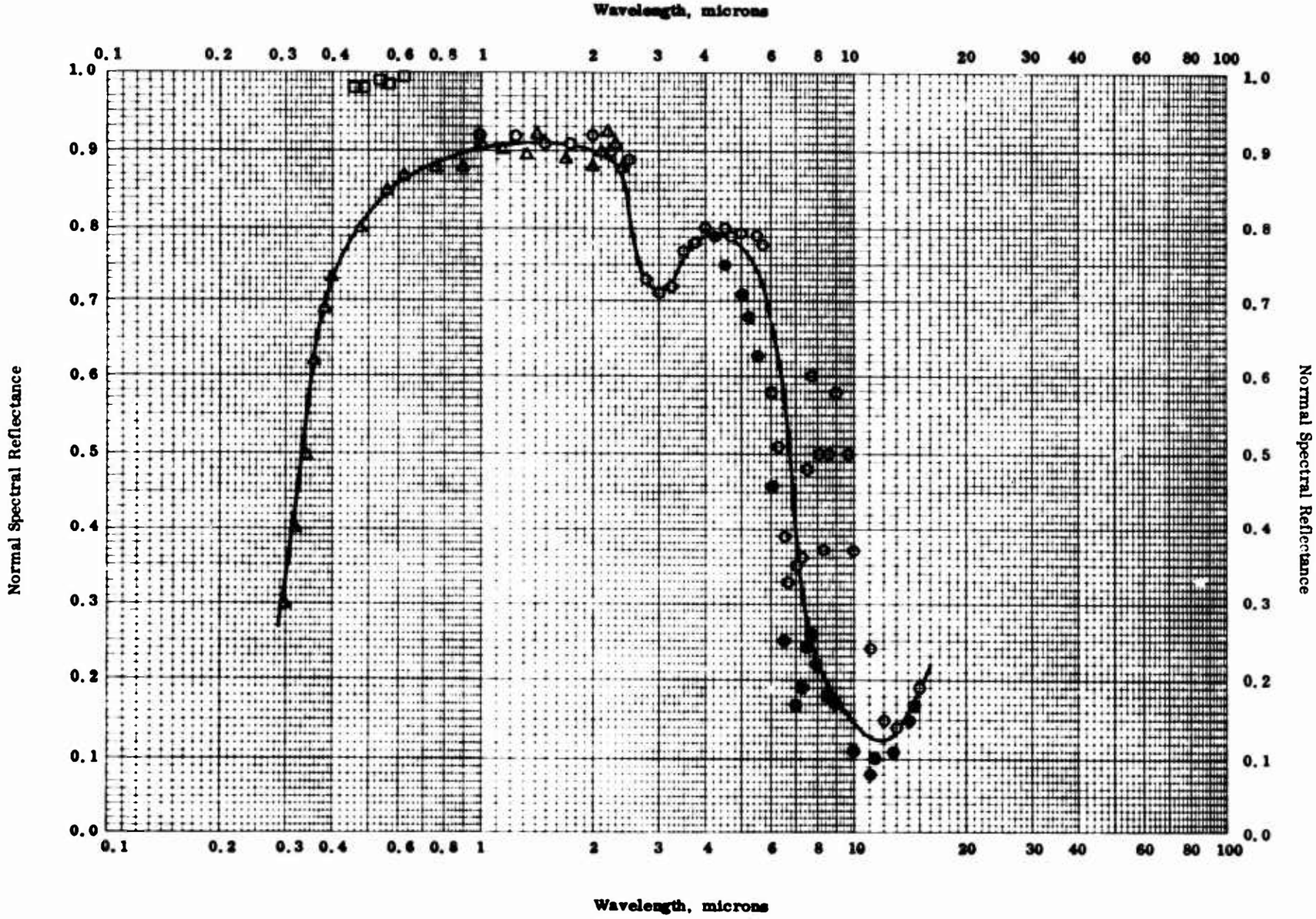


NORMAL SPECTRAL EMITTANCE -- MAGNESIUM OXIDE

NORMAL SPECTRAL EMITTANCE -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Wavelength μ	Temp. Range, °K	Rept. Error%	Sample Specifications	Remarks
O	59-15	0.665	1200-1783		MgO.	Fused material.

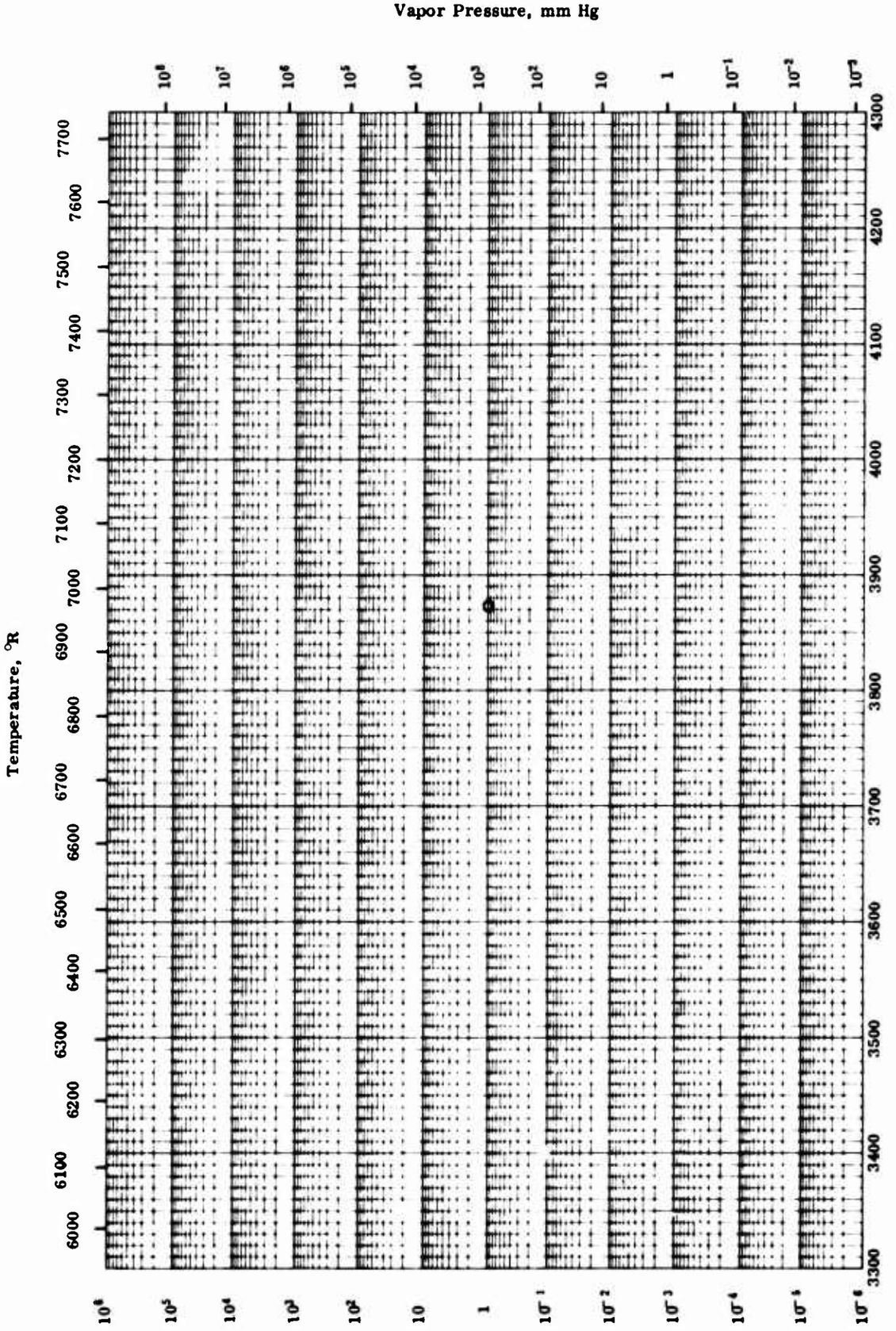


NORMAL SPECTRAL REFLECTANCE -- MAGNESIUM OXIDE

NORMAL SPECTRAL REFLECTANCE -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
○	54-27	298	1-15		MgO; 0.036 in. thickness with polished Al background.	Hemispherical illumination, 5 degree viewing.
●	54-27	298	4.25-15		MgO; 0.04 in. thickness with black paint background.	Same as above.
□	48-3	298	0.458-0.625		MgO.	Burning Mg ribbon.
△	57-27	298	0.3-2.4	±4	MgO.	Data taken from smoothed curve; 6 - 9 degree illumination, hemispherical viewing; $MgCO_3$ as reference standard.

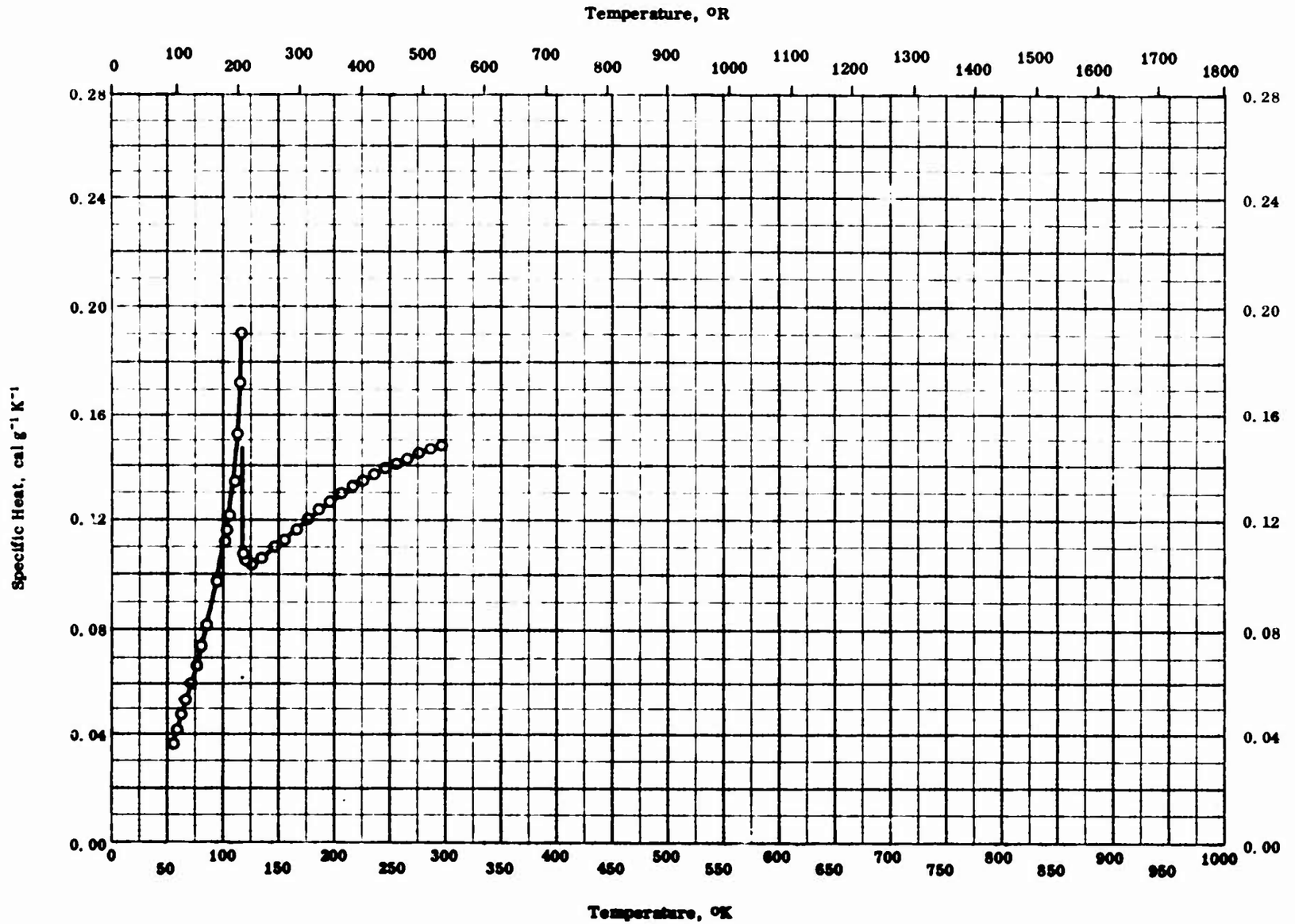


VAPOR PRESSURE -- MAGNESIUM OXIDE

VAPOR PRESSURE -- MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	49-3	3873		MgO.	

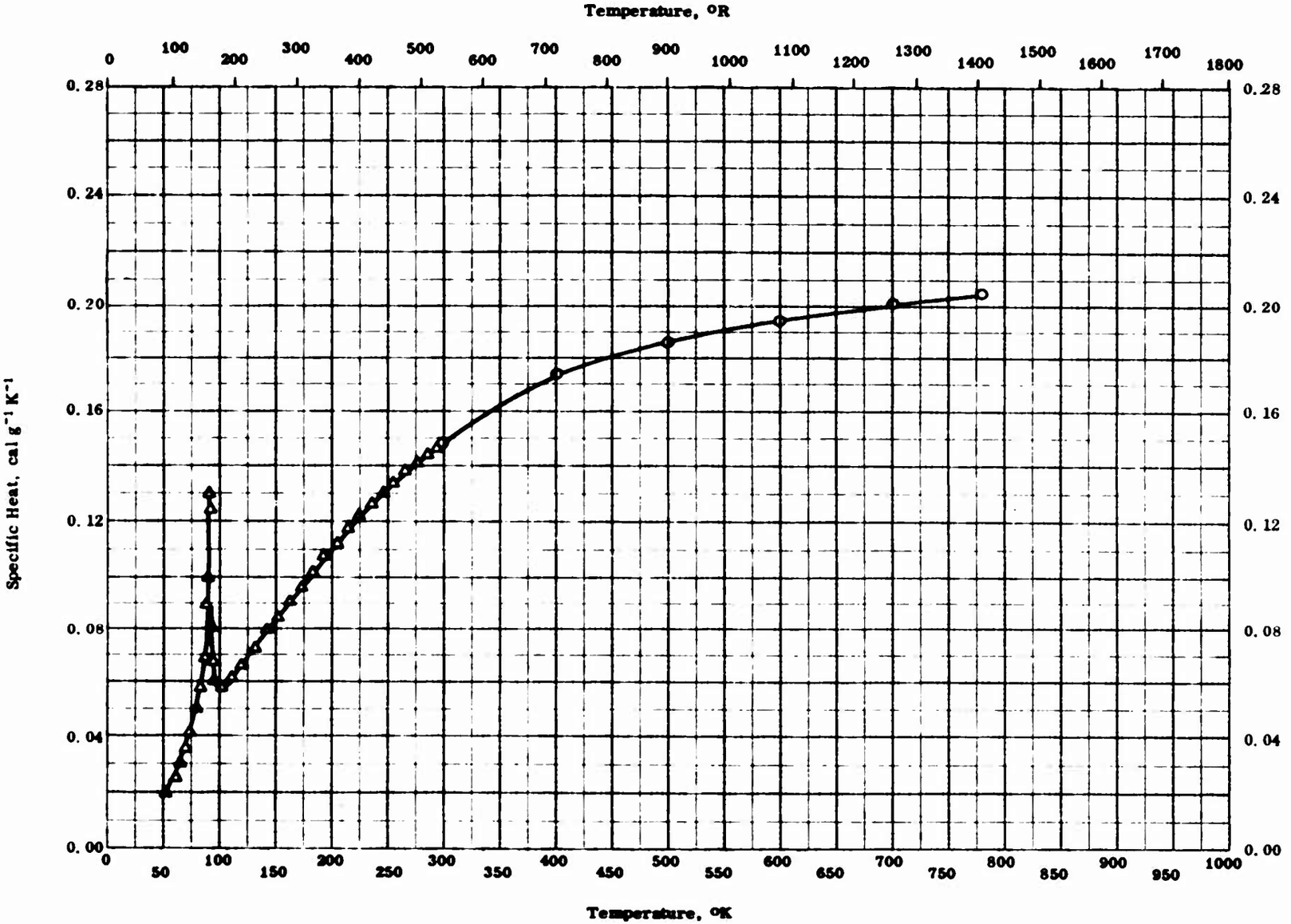


SPECIFIC HEAT -- MANGANESE MONOXIDE

SPECIFIC HEAT -- MANGANESE MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	51-11	54-298		MnO; 99.85 MnO, 0.03 available O_2, and 0.005 S; prepared from electrolytic manganese.	



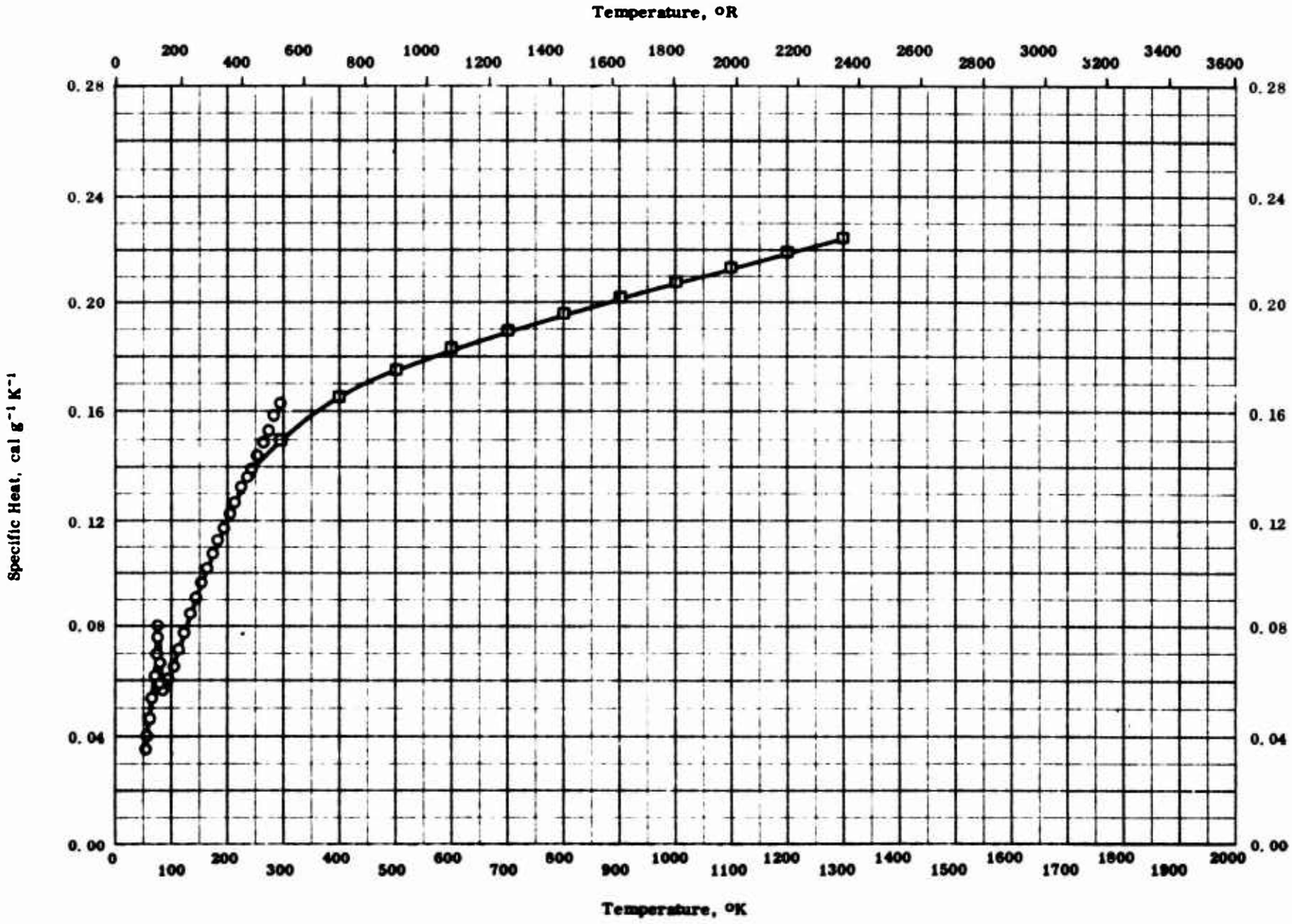
SPECIFIC HEAT -- MANGANESE DIOXIDE

SPECIFIC HEAT -- MANGANESE DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	43-4	298-780		100 MnO_2; density 318.5 lb ft^{-3}.	
△	43-3	53-294		99.88 MnO_2.	Pulverized and heated at 500 C in a stream of pure oxygen.

TPRC

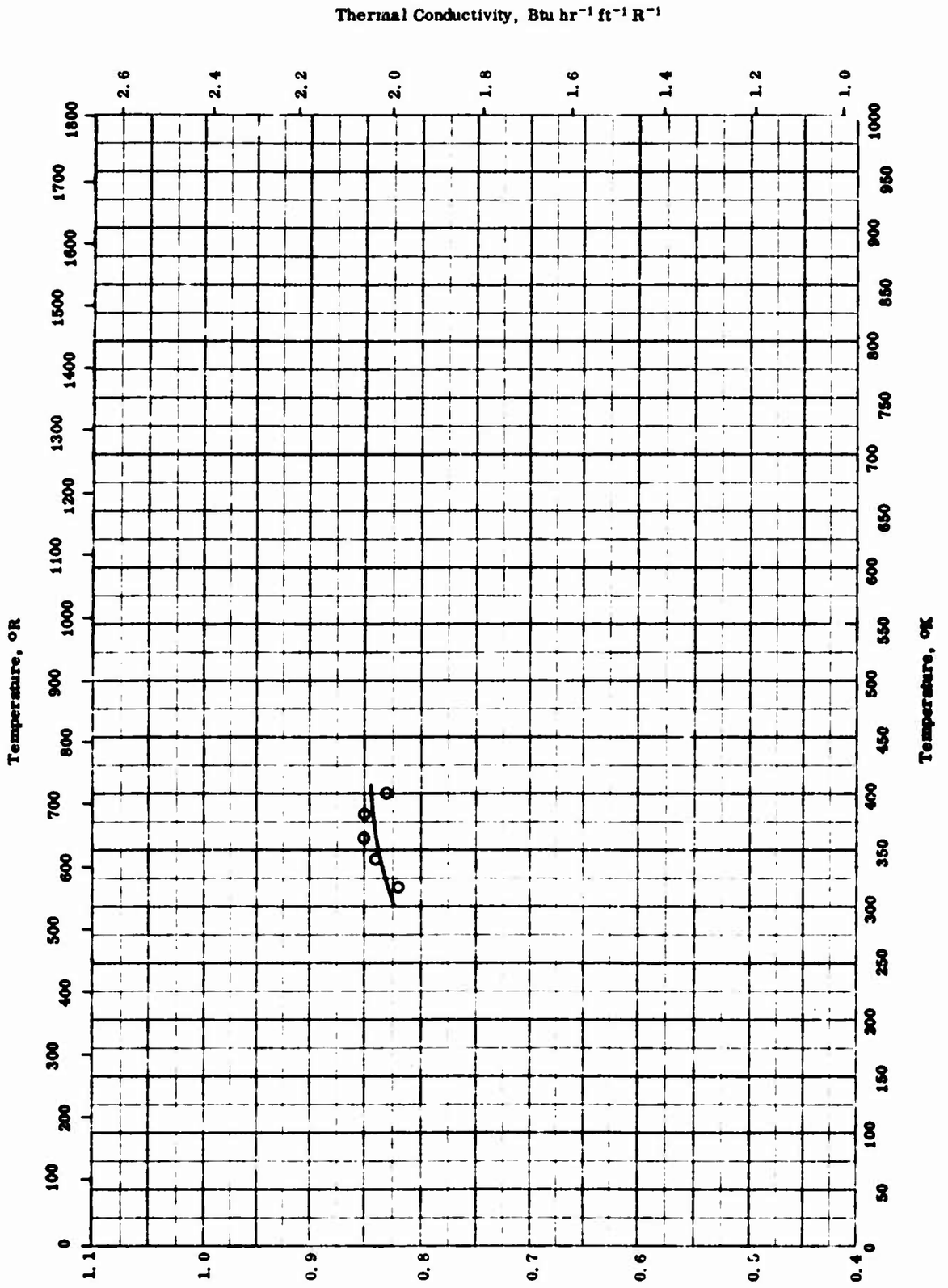


SPECIFIC HEAT -- MANGANESE SESQUIOXIDE

SPECIFIC HEAT -- MANGANESE SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-16	54-298		Mn_2O_3; 69.64 Mn, and 10.13 O_2; theoretical 69.59 Mn and 10.14 O_2.	
□	54-17	298-1300		Mn_2O_3; 69.64 Mn, and 10.13 O_2.	

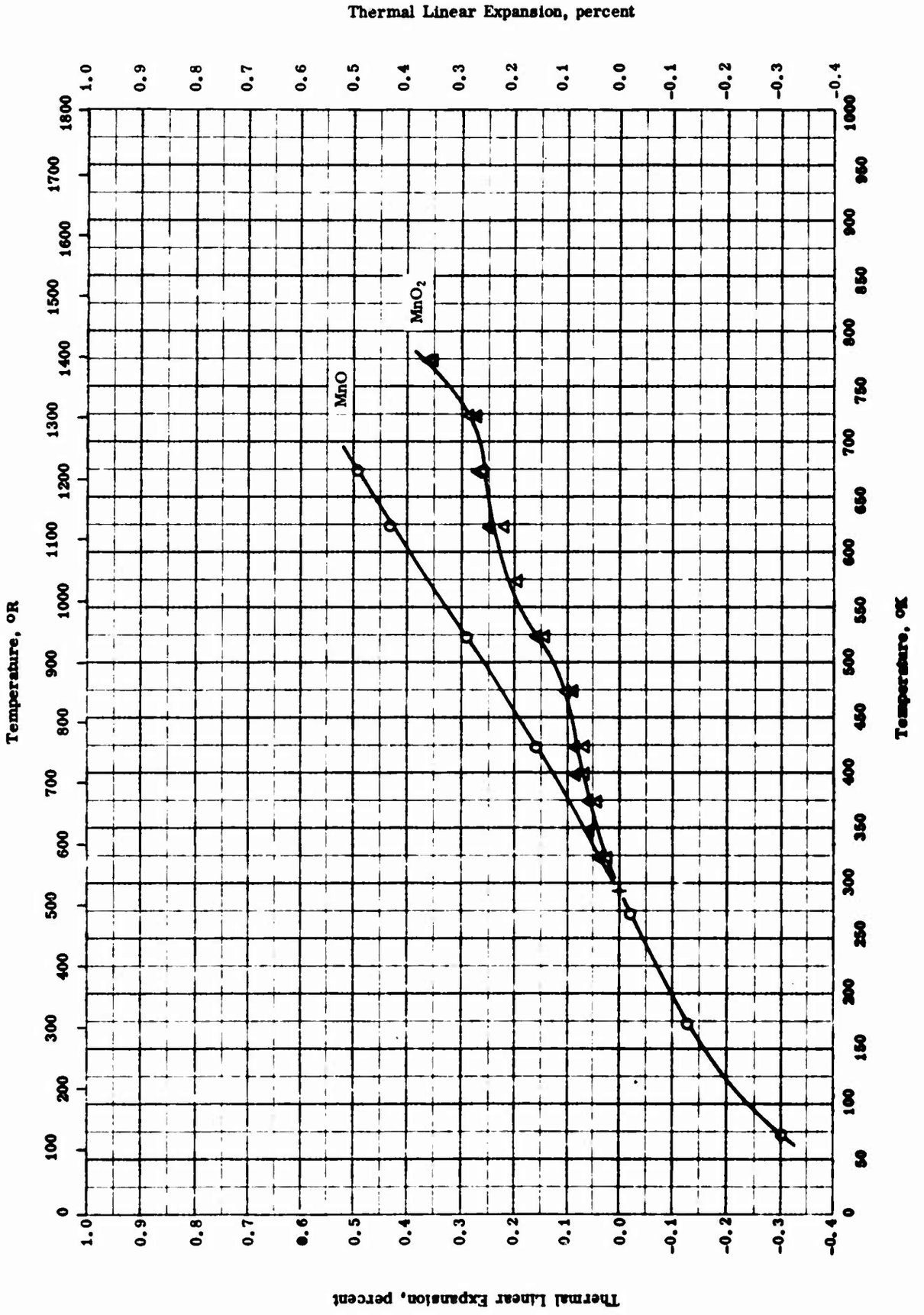


THERMAL CONDUCTIVITY -- MANGANOMANGANIC OXIDE

THERMAL CONDUCTIVITY -- MANGANOMANGANIC OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	52-4	318-400		Mn_3O_4; density 4.21 g cm^{-3} and water absorption 0.024%.	Fired at 2325 F.



THERMAL LINEAR EXPANSION -- MANGANESE OXIDES

Thermal Linear Expansion, percent

THERMAL LINEAR EXPANSION -- MANGANESE OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
△	62-35	298-773		MnO_2.	Prepared by thermal decomposition of manganous nitride solution; ground to pass a 200 mesh screen; Fe-K_{Al} radiation used in x-ray method; measured parallel to a-axis in air.
▲	62-35	298-773		MnO_2.	Same as above except measured parallel to c-axis.
○	48-9	73-673		MnO.	N_2 atm.

PROPERTIES OF MOLYBDENUM OXIDES

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	4.692*	293*
Melting Point	1068.36	1923.1
Heat of Fusion	87.1	156.8
Heat of Sublimation	177_{850K}	319_{1530R}

*For MoO_3 only; handbook of Chemistry and Physics (Ref. 64-16)

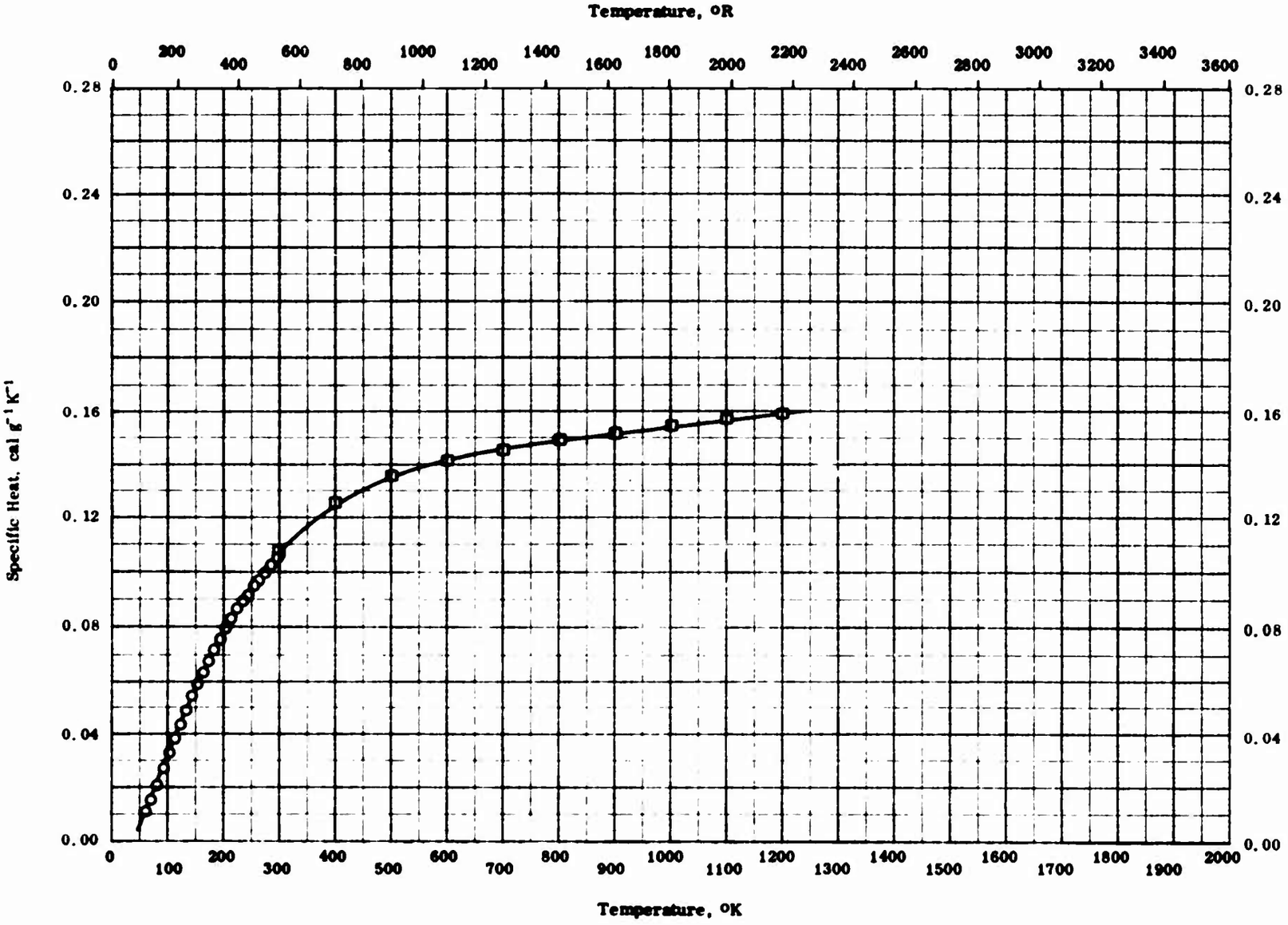
REPORTED VALUES

Melting Point	K	R
□ MoO_3	1068.36	1923.1
Heat of Fusion	**cal g^{-1}**	**Btu lb^{-1}**
○ MoO_3	87.1	156.8
Heat of Sublimation	**cal g^{-1}**	**Btu lb^{-1}**
△ Not given	442.5_{928K}	796.5_{1671R}
◇ Vapor phase Mo_3O_9	$186 \pm 3_{850K}$	$335 \pm 6_{1530R}$
▽ Vapor phase Mo_4O_{12}	$163 \pm 3_{850K}$	$293 \pm 5_{1530R}$
◁ Vapor phase Mo_5O_{15}	$147 \pm 5_{850K}$	$264 \pm 9_{1530R}$
▷ Vapor phase mixtures of Mo_3O_9, Mo_4O_{12}, and Mo_5O_{15}	177_{850K}	319_{1530R}

PROPERTIES OF MOLYBDENUM OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-9	1068		MoO_3; 66.8 ± 0.07 Mo, 0.001 insoluble in NH_3, 0.005 non-volatile with HCl at 450 C, and spectroscopic trace of heavy metals and alkali metals.	Δh_f by drop method.
□	53-9	1068		Same as above.	
△	41-1	928		Not given.	Δh_s from vapor pressure data.
◇	ND-1	850		Not given but vapor phase Mo_3O_9.	Same as above.
▽	ND-1	850		Not given but vapor phase Mo_4O_{12}.	Same as above.
◁	ND-1	850		Not given but vapor phase Mo_5O_{15}.	Same as above.
▷	ND-1	850		Not given but vapor mixture of phases 66 Mo_3O_9, 29 Mo_4O_{12} and Mo_5O_{15}.	Δh_s computed from Δh_s and vapor composition determined by using mass-spectrometer.

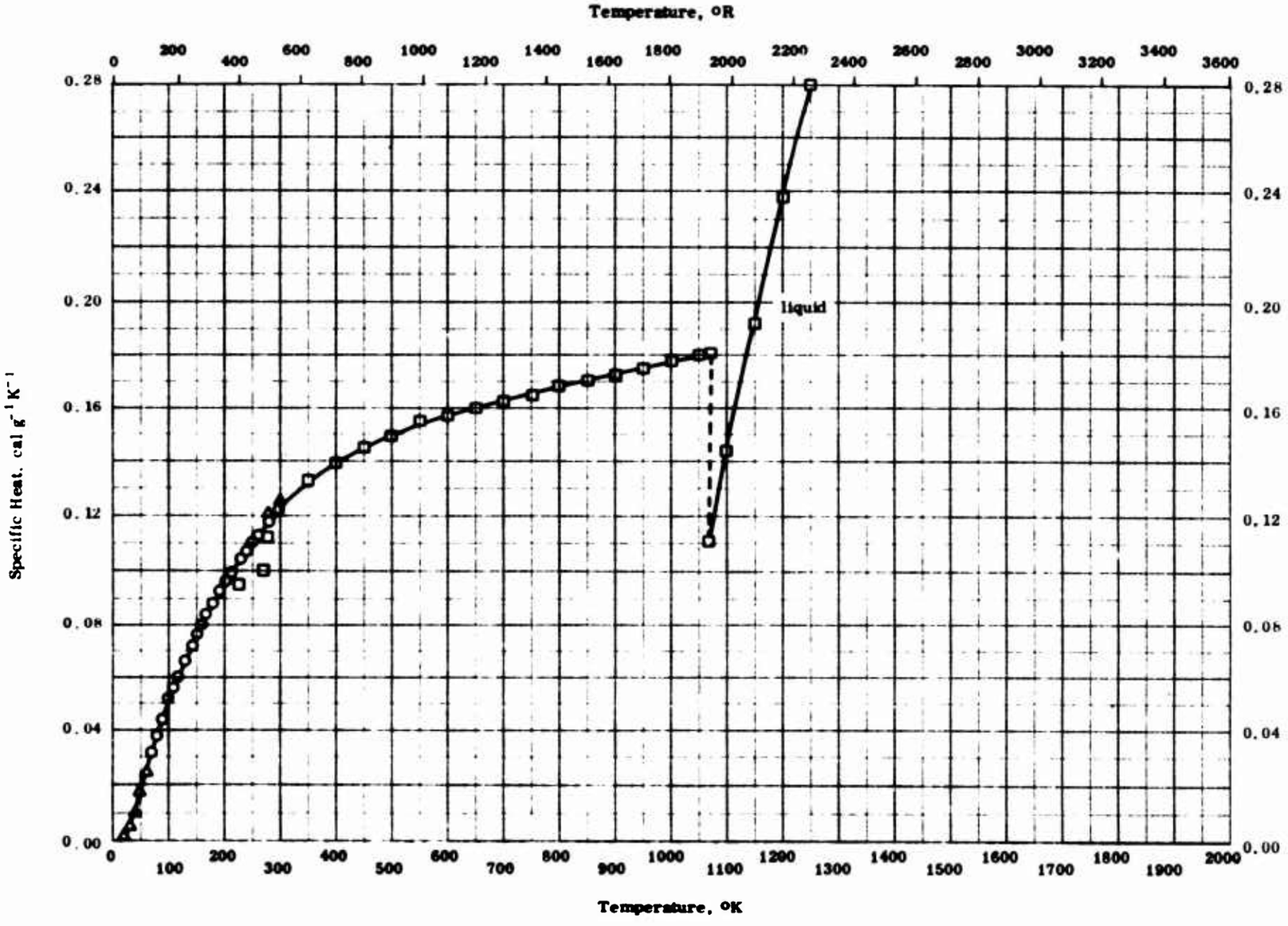


SPECIFIC HEAT -- MOLYBDENUM DIOXIDE

SPECIFIC HEAT -- MOLYBDENUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	58-9	53-298		MoO_2.	
□	65-1	300-1200	1.8	MoO_2.	



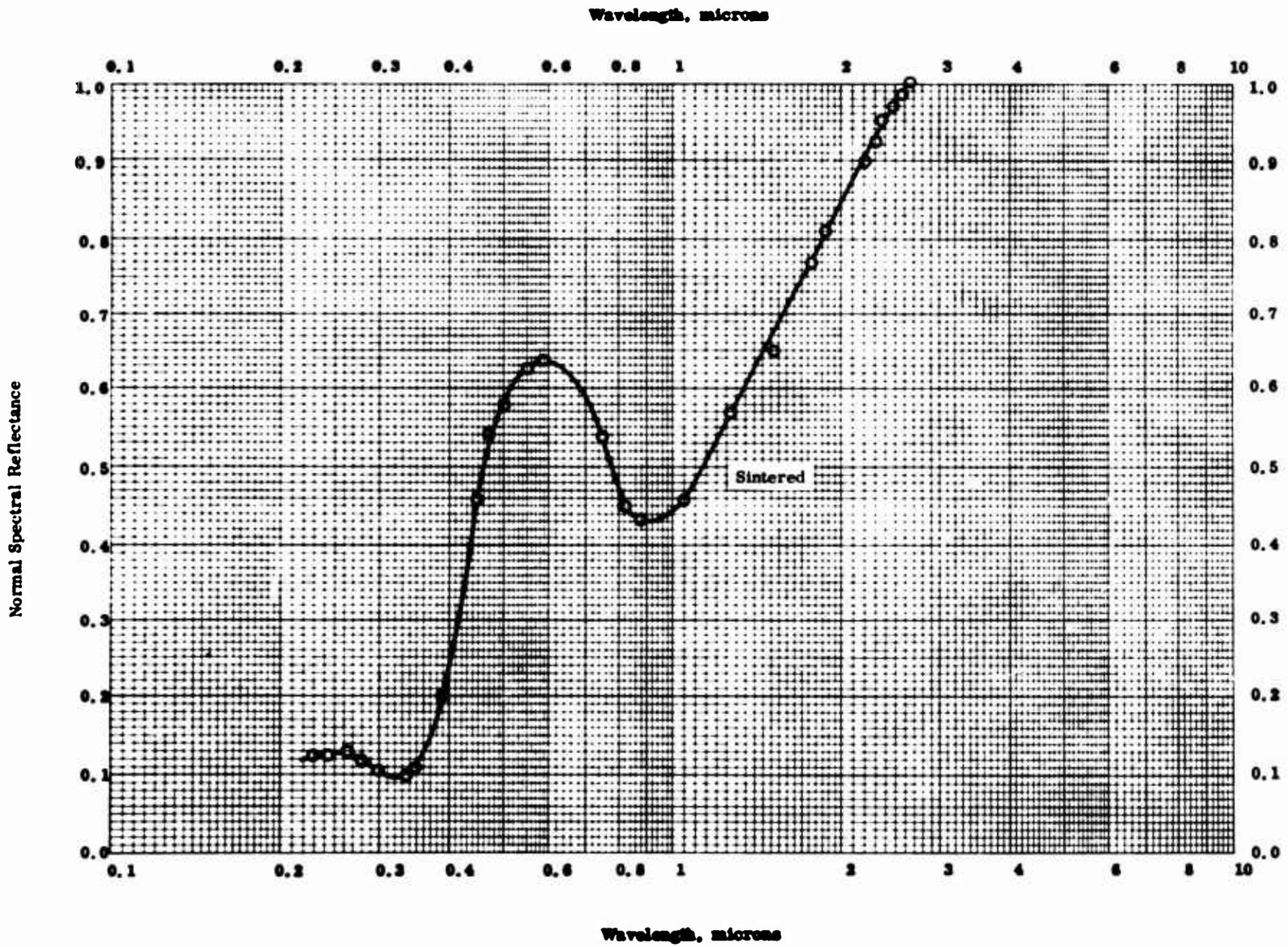
SPECIFIC HEAT -- MOLYBDENUM TRIOXIDE

SPECIFIC HEAT -- MOLYBDENUM TRIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	43-5	70-299		99.9 MoO_3; small transparent rhombic crystals.	
□	53-9	70-1300		MoO_3; 66.8 Mo, 0.005 non-volatile with HCl at 450 C, 0.001 insoluble in HNO_3, and traces of alkali metals.	
△	56-9	19-300		C. P. grade MoO_3.	

TPRC



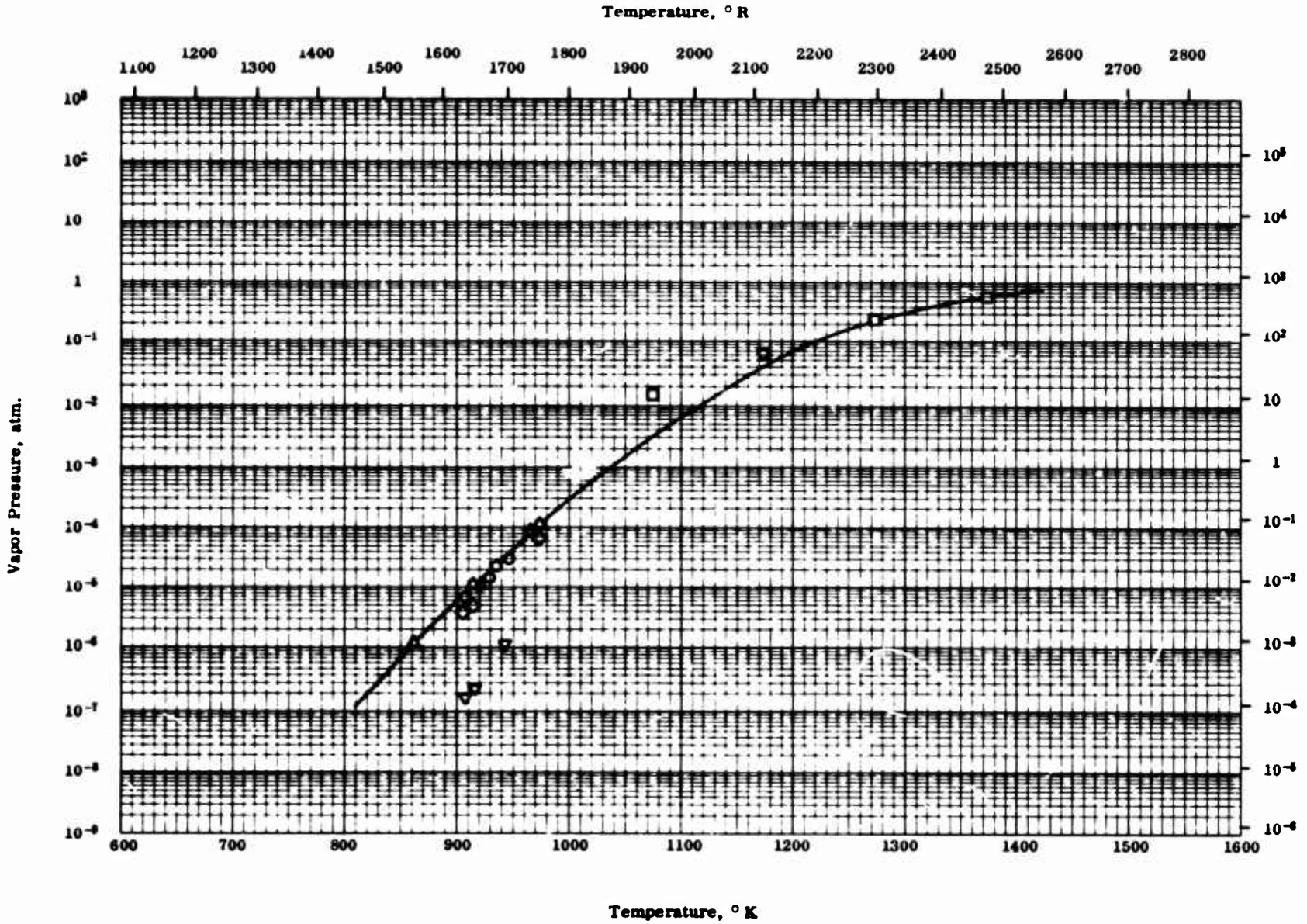
NORMAL SPECTRAL REFLECTANCE -- MOLYBDENUM TRIOXIDE

NORMAL SPECTRAL REFLECTANCE -- MOLYBDENUM TRIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
O	63-26	298	0.23-2.65	5	MoO_3; 0.095 in. thickness plate.	Sintered at 873 K for 1 hr; data taken from a curve; normal incidence, hemispherical viewing; MgO as reference standard.

TPRC



VAPOR PRESSURE -- MOLYBDENUM OXIDES

VAPOR PRESSURE -- MOLYBDENUM OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	41-1	908-948		MoO_3.	
□	56-6	1073-1373		Chemically "pure" MoO_3.	
△	ND-1	861-973		Mo_3O_9 vapor over MoO_3.	
◇	ND-1	905-973		Mo_4O_{12} vapor over MoO_3.	
▽	ND-1	908-943		Mo_5O_{15} vapor over MoO_3.	

PROPERTIES OF NEODYMIUM OXIDES

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density	7.277*	454*
Melting Poing	2545*	4581*

* For Nd_2O_3 only.

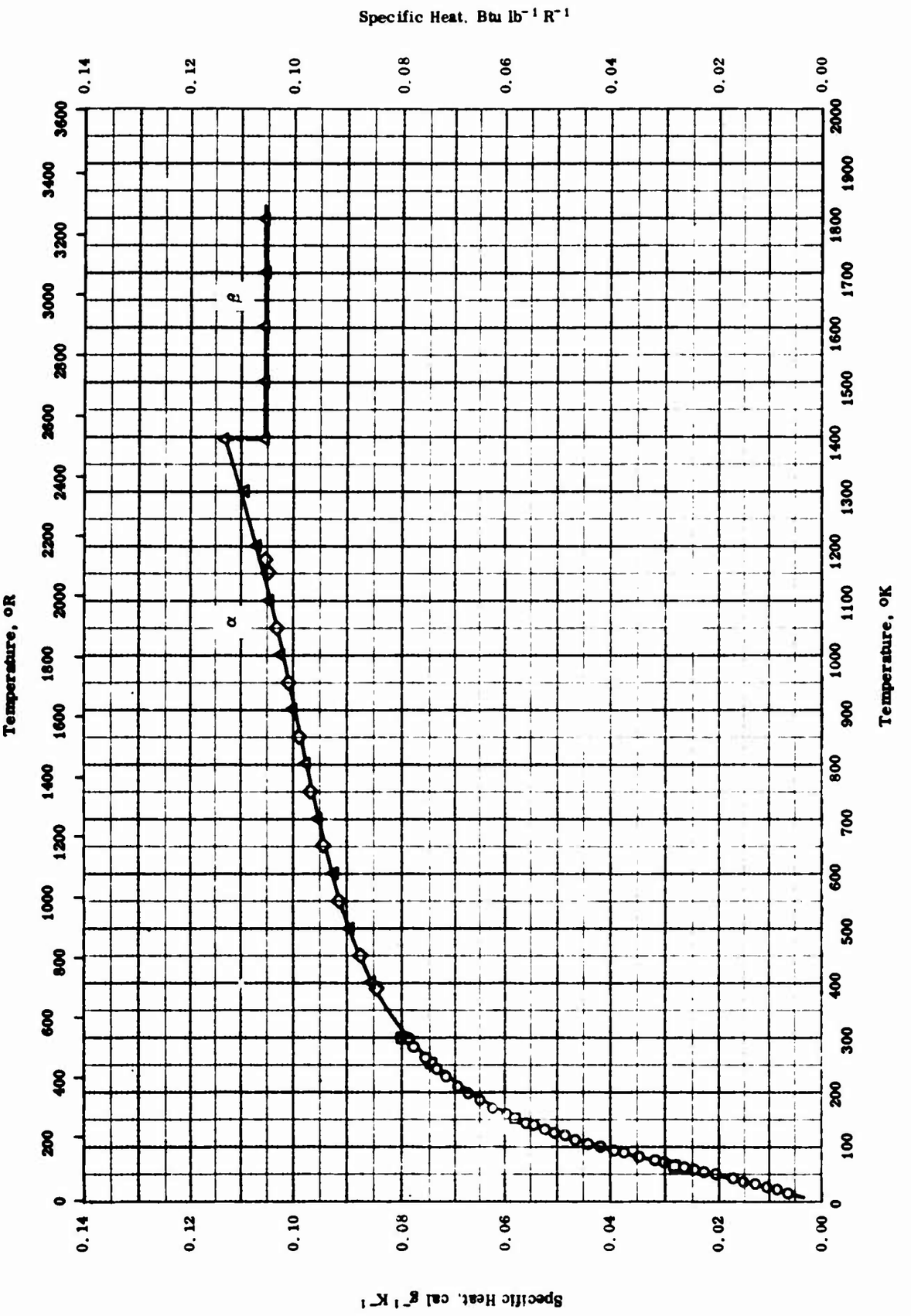
REPORTED VALUES

Density	g cm^{-3}	lb ft^{-3}
□ NdO	8.18	510.0
△ Nd_2O_3	7.277	454.1
Melting Point	**K**	**R**
○ Nd_2O_3	2545 ± 20	4581 ± 36

PROPERTIES OF NEODYMIUM OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-15	2525-2565		99 Nd_2O_3.	M. P. by inspection after heating in constant temperature furnace.
□	62-16	298		NdO.	
△	62-16	298		Nd_2O_3 - A.	

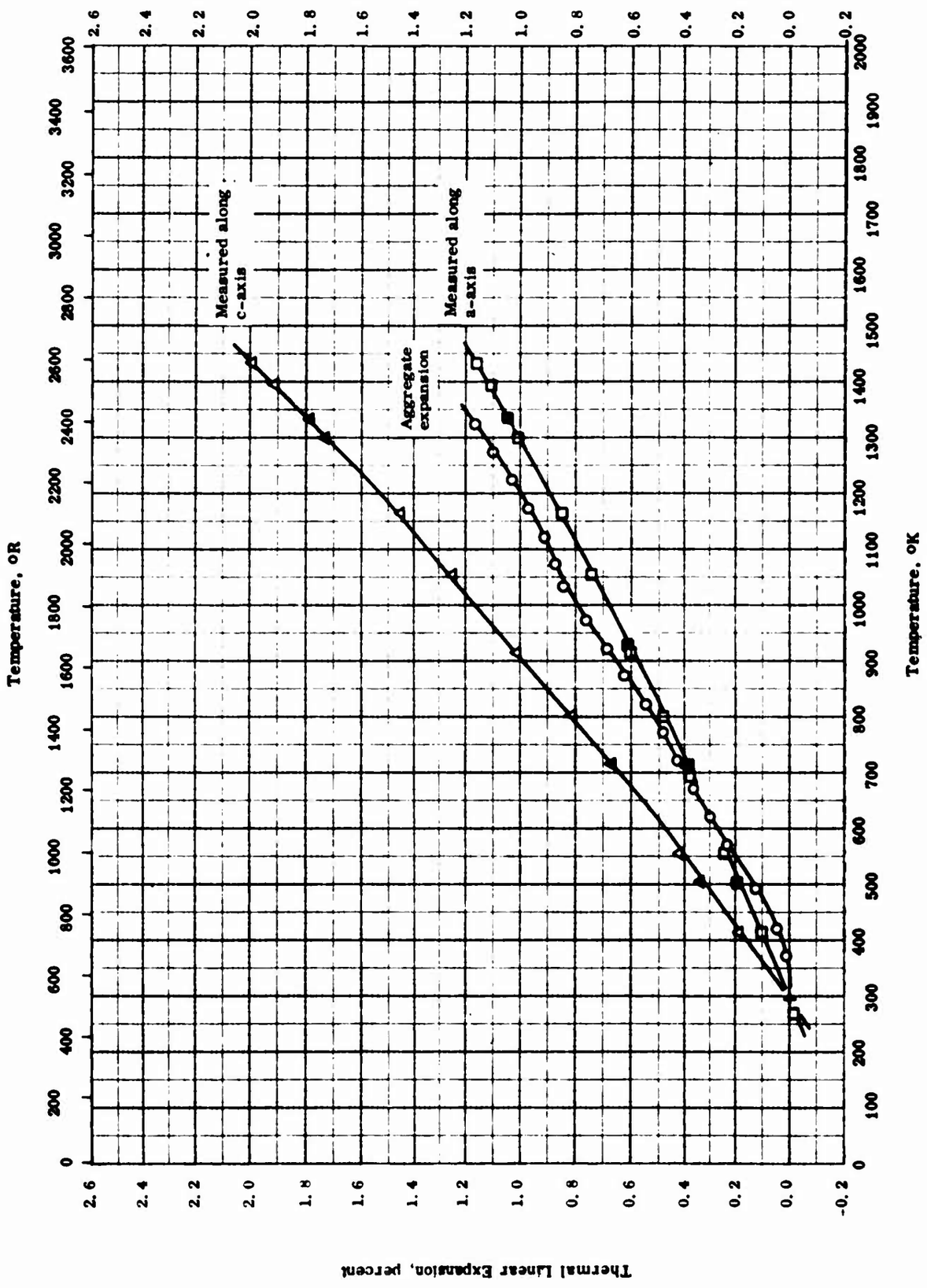


SPECIFIC HEAT -- NEODYMIUM OXIDE

SPECIFIC HEAT -- NEODYMIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	59-6	18-298		99.9 Nd_2O_3, 0.1> Pr_6O_{11}, and 0.1> Sm_2O_3.	Heated to constant weight at 950 C for 24 hrs in air to decompose hydroxides or carbonates.
□	61-13	5-346		99.9 Nd_2O_3.	Pelleted under 2000-4000 psi and fired at 1170 K; under helium atm.
△	62-11	298-1795	0.2	99.9 Nd_2O_3; hexagonal structure.	Under helium atm.
◇	51-7	383-1171	0.4	99.5 Nd_2O_3.	

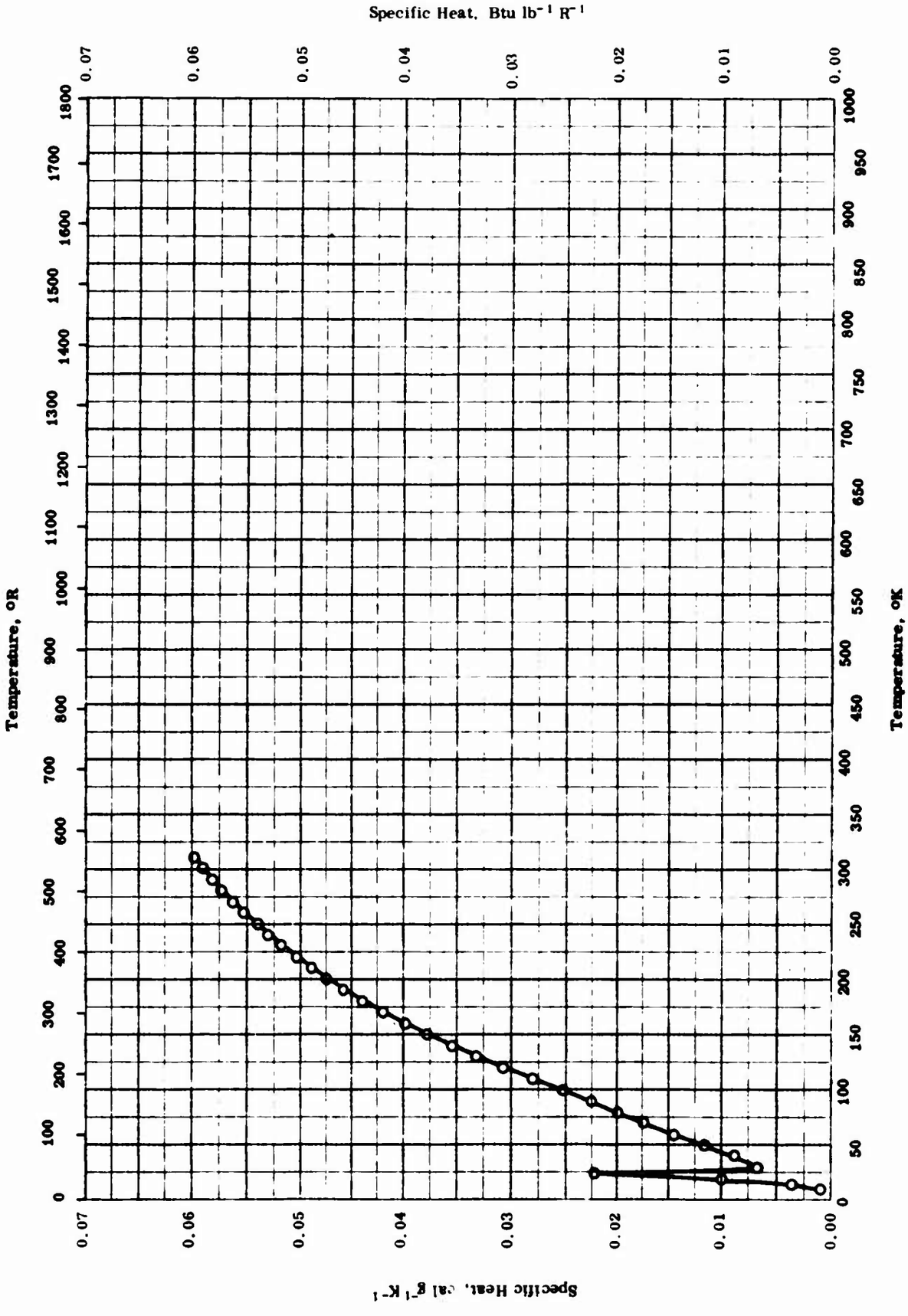


THERMAL LINEAR EXPANSION -- NEODYMIUM OXIDE

THERMAL LINEAR EXPANSION -- NEODYMIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	64-26	308-1323		Nd_2O_3; < 0.02 Sm, < 0.02 Dy, <0.01 Gd, <0.005 Eu, 0.005 Fe, 0.002 Si, and 0.0005 Mg; randomly oriented polycrystal.	Dry-pressed at 20,000 psi in double-acting steel die into pellets 1/2 in. in diameter by 2 in. long, sintered at 1450 C for 1 hr in an oxidizing atm, furnace cooled to 200 C, and transferred to a vacuum desiccator to cool to room temperature; temperature control maintained at a rate of 3 to 5 C min^{-1}.
□	61-41	273-1431	1.1-6.0	Nd_2O_3, code 629.9 from Lindsay Chemical Co., West Chicago, Ill.; 99.9 Nd_2O_3 in regard to total rare-earth content; 0.03-0.3 Sm, 0.01-0.1 Ca, 0.001-0.01 Mg, and 0.0003-0.003 Si; hexagonal, rare-earth oxide type A.	Sintered at 1100 C for 24 hrs, packed into alumina sample holder, resintered at 1100 C for 12 hrs, cooled to 750 C, and placed in a vacuum desiccator for storage; measured along a-axis with x-ray diffractometer.
■	61-41	508-1431	1.1-610	Same as above.	Cooling cycle for above sample.
△	61-41	273-1431	1.1-6.0	Same as above.	Same as heating cycle for above sample except measured along c-axis.
▲	61-41	273-1431	1.1-6.0	Same as above.	Cooling cycle for above sample.

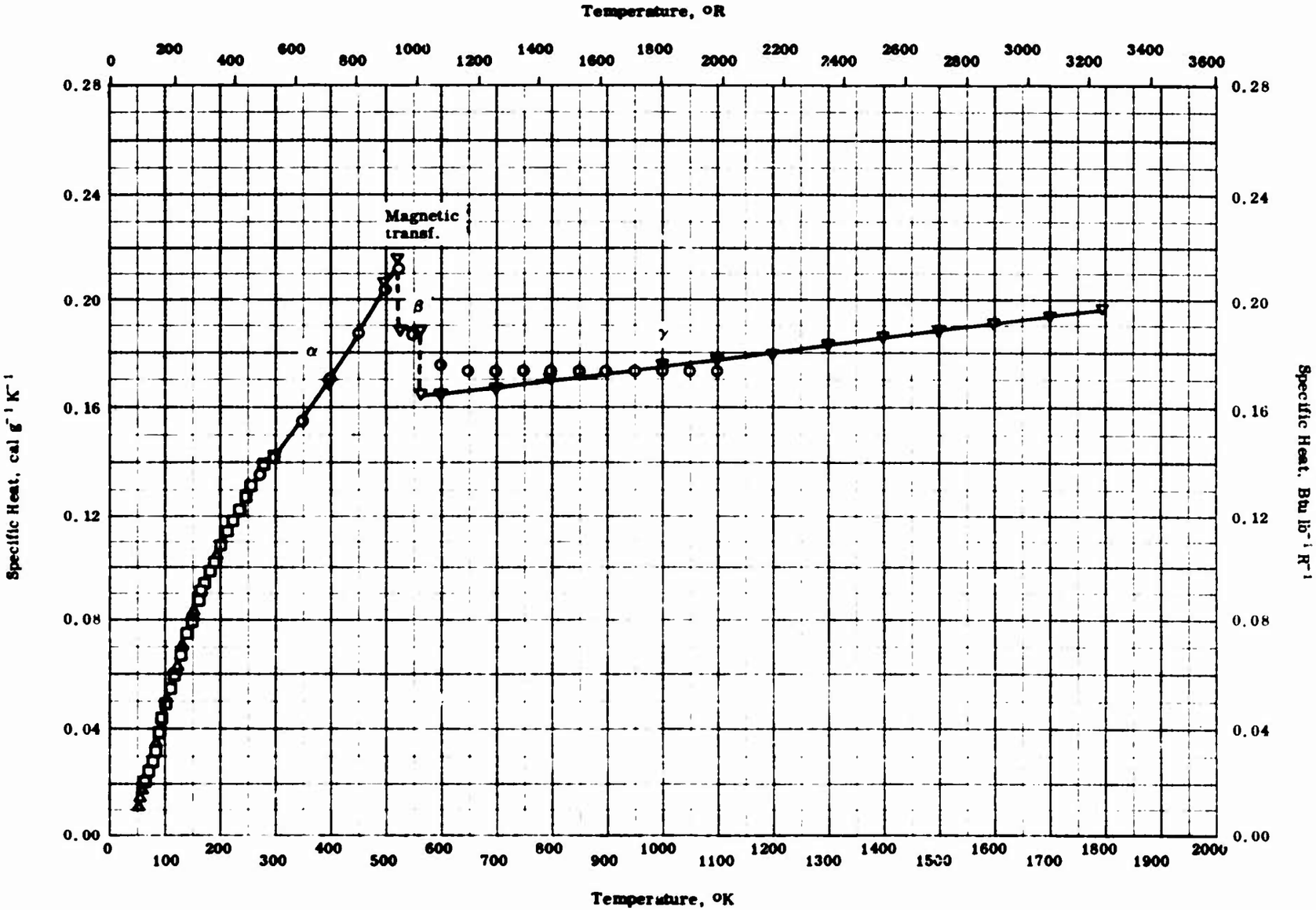


SPECIFIC HEAT -- NEPTONIUM DIOXIDE

SPECIFIC HEAT -- NEPTONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	53-15	11-312		99.9 NpO_2 and 0.1 > total of Ca, Cr, Fe.	Np^{237} prepared by U^{238} (n, 2n) U^{237} β^{-1} Np^{237}; hydroxide precipitated from acid solution and ignited to constant weight in air in Pt boat at 700 C.



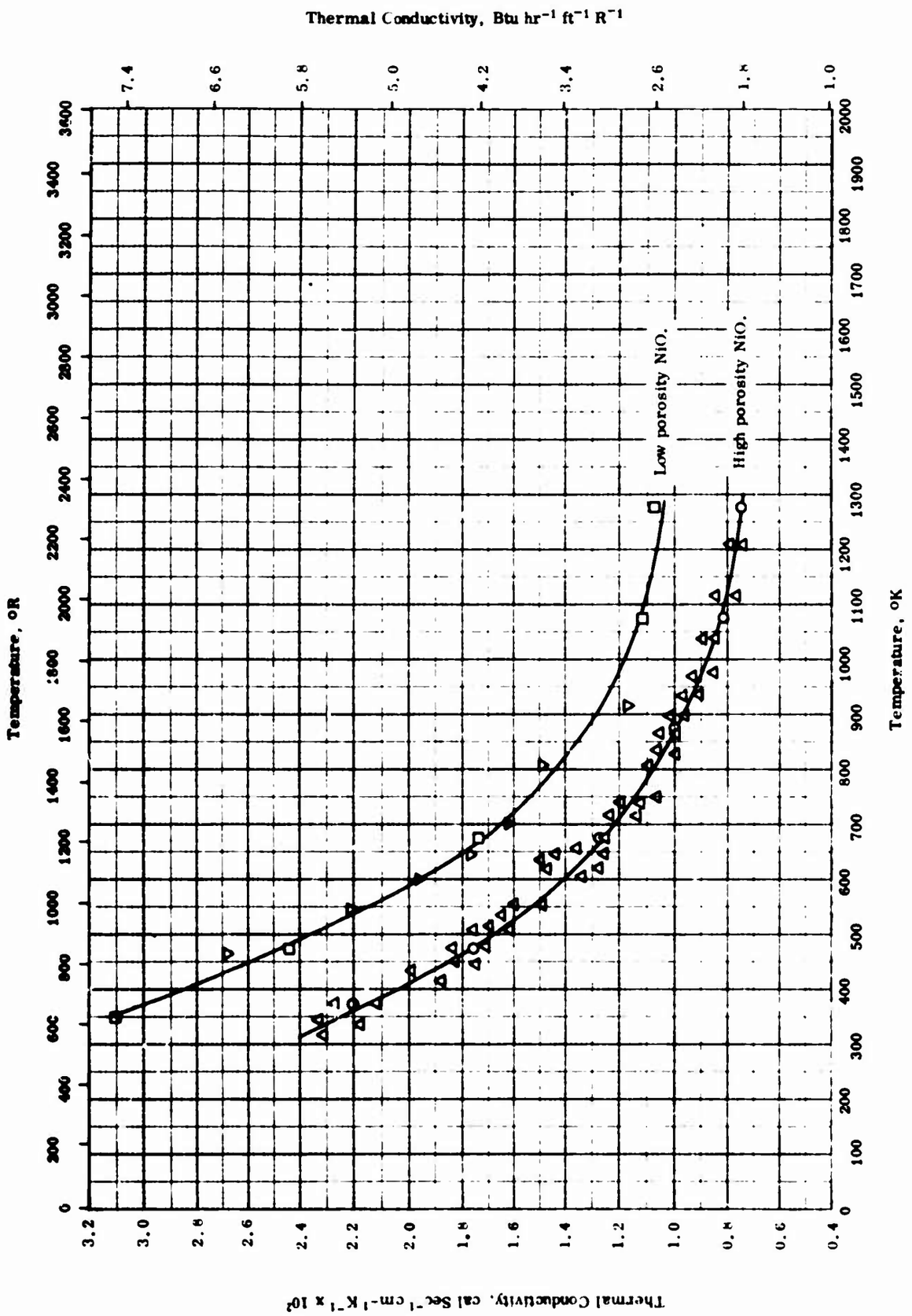
SPECIFIC HEAT -- NICKEL MONOXIDE

SPECIFIC HEAT -- NICKEL MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	55-17	273-1100		NiO; 78.51 - 78.54 Ni and 0.01 - 0.1 Si.	Prepared by decomposing $Ni(NO_3)$ · 6 H_2O and heating 8 hrs at 1000 C.
□	40-2	68-296		NiO with 0.2 > impurities; transparent cubic crystals.	
△	57-12	54-295		99.96 NiO, 0.05 CoO, 0.02 acid insoluble, and 0.01 Na_2O; prepared from reagent grade hexahydrates of nickelous nitrate and nickelous sulfate.	
▽	58-11	298-1800	0.4	99.96 NiO, 0.05 CoO, 0.02 acid insoluble, and 0.01 Na_2O.	

TPRC



THERMAL CONDUCTIVITY -- NICKEL MONOXIDE

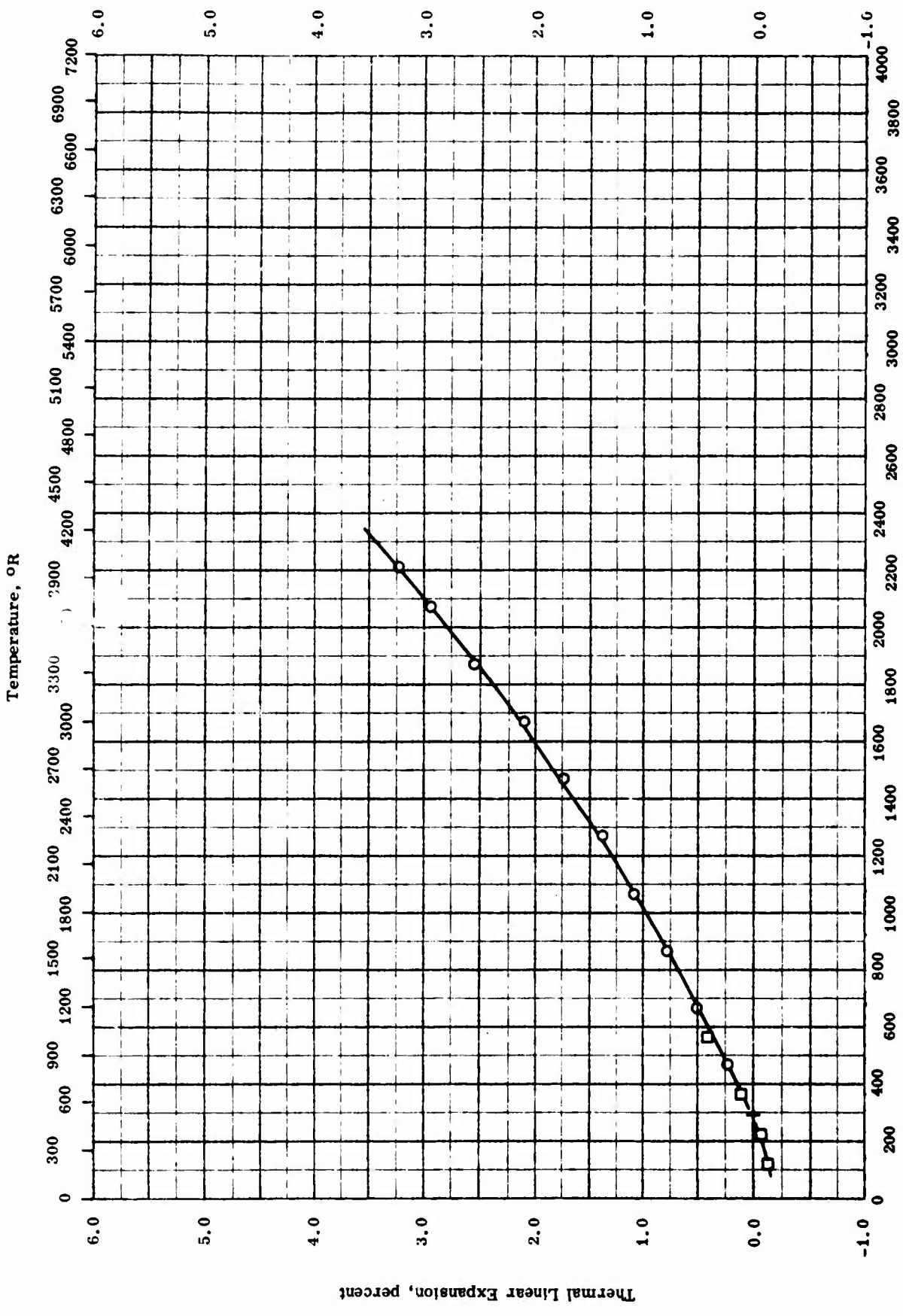
THERMAL CONDUCTIVITY -- NICKEL MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-1	373-1273		NiO; polycrystal; density 315 lb ft^{-3}; porosity 25.7%.	Prepared by calcining c. p. NiO at 1000 C, pressing, and firing at 1500 C in oxidizing atm.
□	54-2	350-1278		NiO.	Data corrected by author to zero porosity.
▽	58-2	467-913	±2	Commercially pure -325 mesh powder NiO; density 6.00 g cm^{-3} and porosity 11.5%.	Calcined at 1000 C for 1 hr and fired in an oxidizing atm at 1500 C for 4 hrs; average of two runs.
△	54-3	318-1209		NiO; bulk density 5.05 g cm^{-3} and total porosity 32%.	

TPRC

THERMAL LINEAR EXPANSION -- NICKEL MONOXIDE



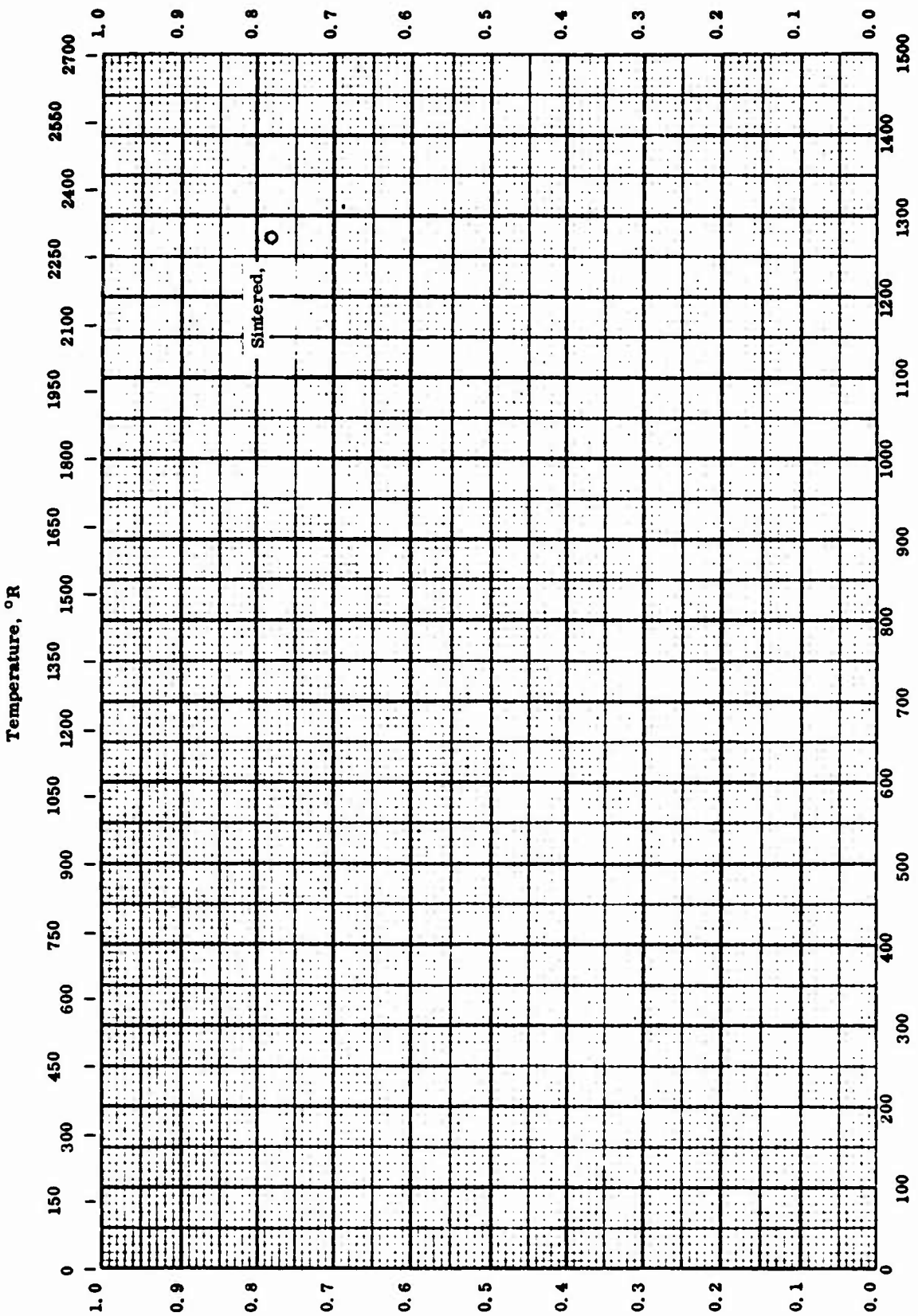
THERMAL LINEAR EXPANSION -- NICKEL MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	64-24	298-2203		NiO; prepared from reagent-grade nickel sulphate; density of as fabricated sample 6.44 g cm^{-3}, after 1800 C heat treatment 6.57 g cm^{-3}, and after first run to 1800 C 6.56 g cm^{-3}; grain size approx 1.5 μ of as fabricated sample, 140 μ after 1800 C heat treatment, 145 μ after first run to 1800 C, and 1 5 μ after second run to 1930 C.	Calcined for 20 hrs at 900 C in air, hot pressed at 10,000 psi and 1000 C for 90 min in O_2 atm into 0.75 in. in diameter by 2 in. long blank, welded two 2 in. blanks together by hot pressing as before, and heat treated to 1800 C for 1 hr in 95 O_2 - 5 N_2 atm; measured in 95 O_2 - 5 N_2 atm; data is average of two runs.
□	48-9	123-673		NiO.	N_2 atm.

TPRC

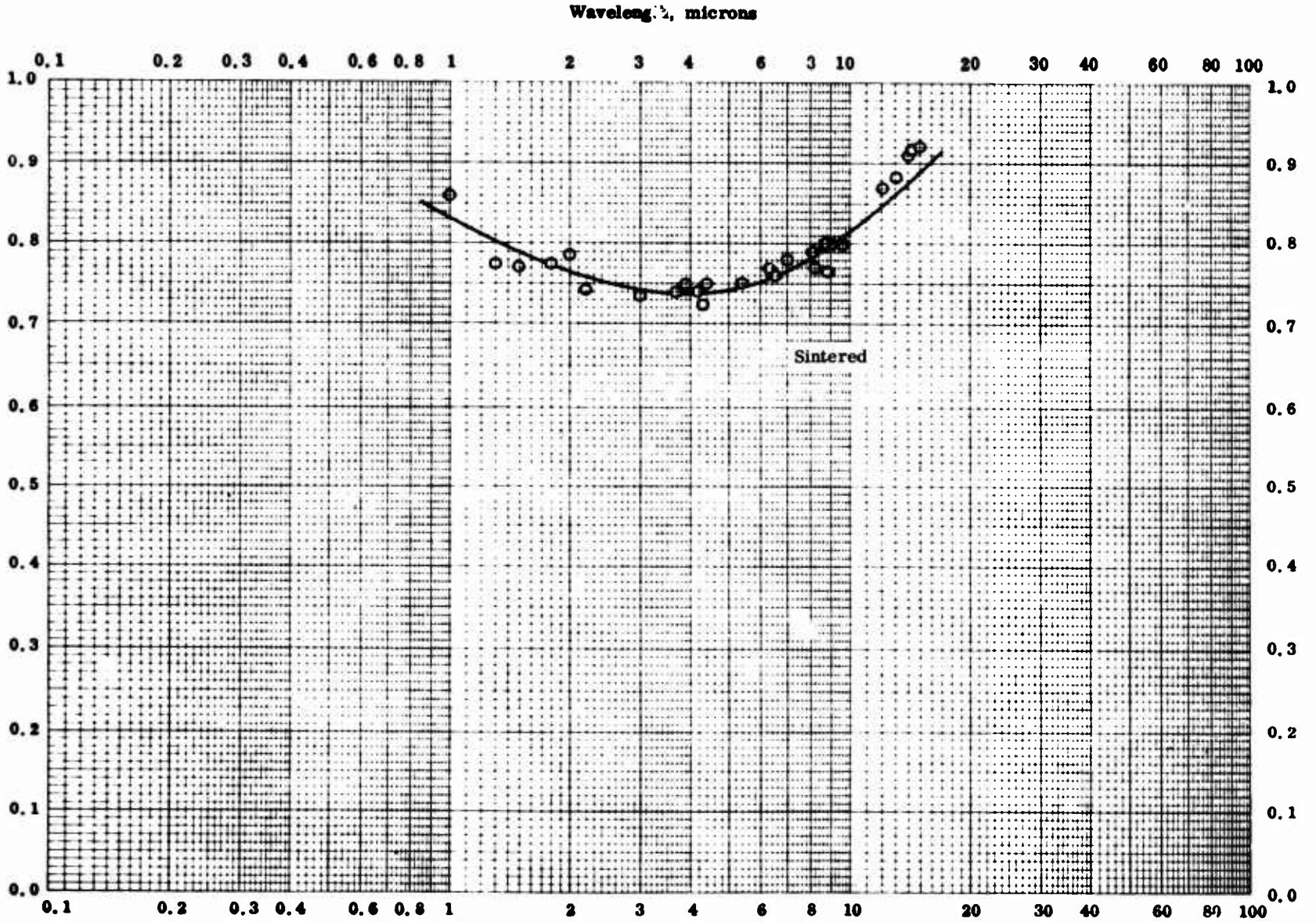
NORMAL TOTAL EMITTANCE -- NICKEL MONOXIDE



NORMAL TOTAL EMITTANCE -- NICKEL MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-26	1273	±8	NiO, 0.046 in. thickness; density 5.32 g cm^{-3}.	Sintered at 1673 K for 2 hrs; measured in argon atmosphere; computed from spectral data.

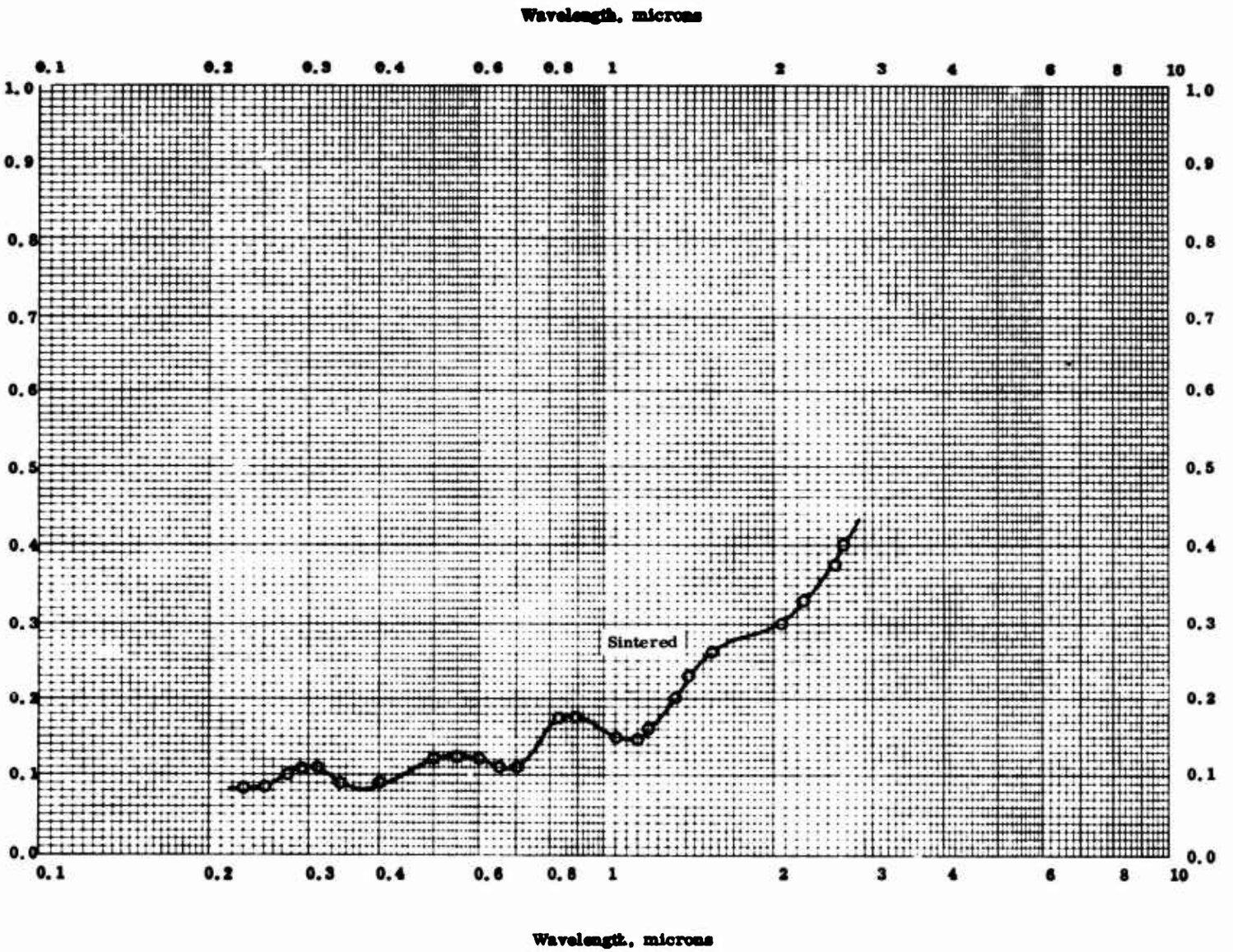


NORMAL SPECTRAL EMITTANCE -- NICKEL MONOXIDE

NORMAL SPECTRAL EMITTANCE -- NICKEL MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
O	63-26	1273	1 - 15		NiO, 0.046 in. thickness, density 5.32 g cm^{-3}.	Sintered at 1673 K for 2 hours; measured in argon atmosphere; data taken from a curve.



NORMAL SPECTRAL REFLECTANCE -- NICKEL MONOXIDE

NORMAL SPECTRAL REFLECTANCE -- NICKEL MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
O	63-26	298	0.23-2.65	5	NiO, pure; plate 0.053 in. thickness; density 4.81 g cm^{-3}.	Sintered at 1773 K for 2 hrs; data taken from a curve; normal illumination, hemispherical viewing; MgO as reference standard.

TPRC

PROPERTIES OF NIOBIUM PENTOXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Melting Point	1769	3184
Heat of Fusion	92.5	167

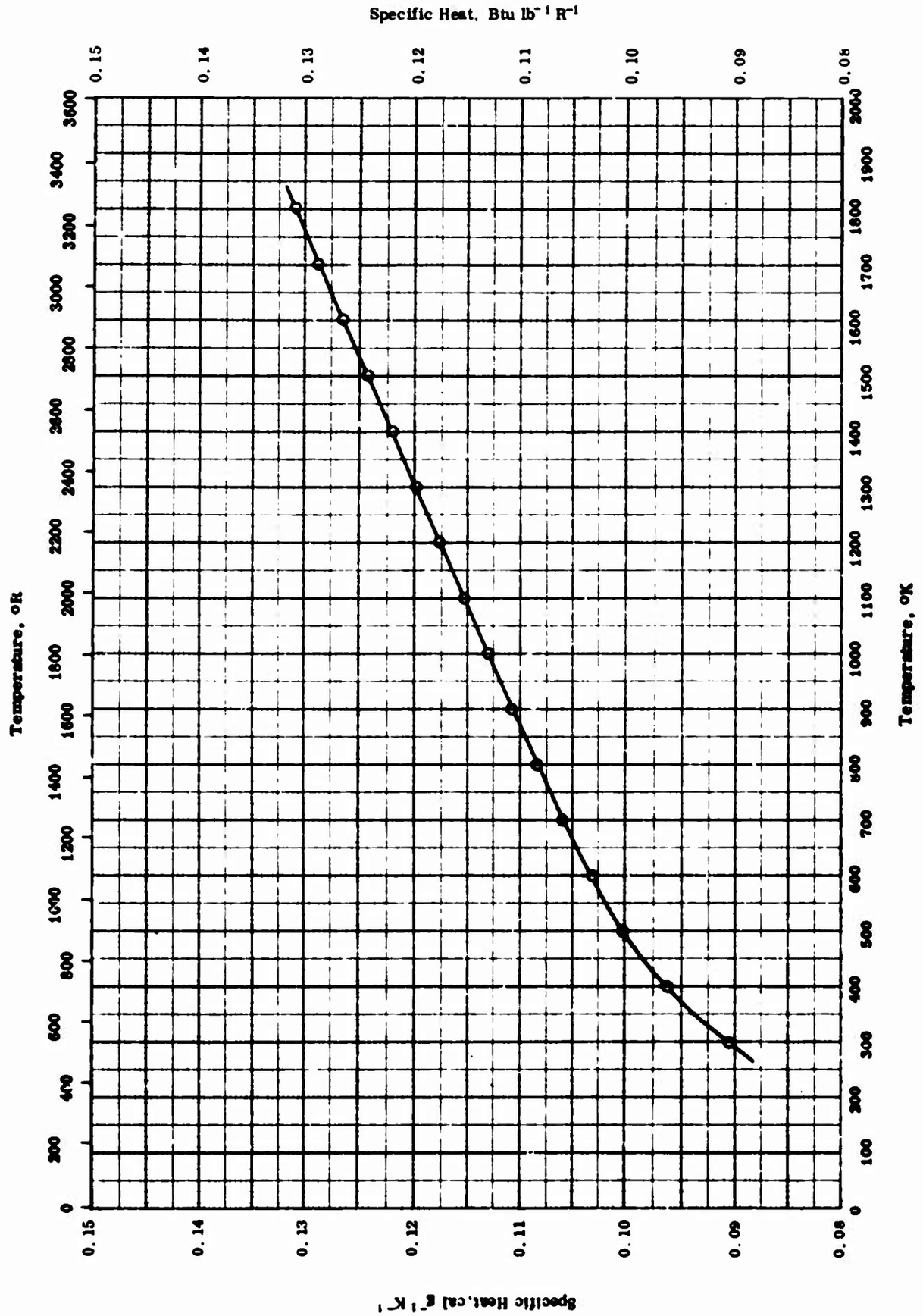
REPORTED VALUES

Melting Point		K	R
	○	1713	3084
	□	1785 ± 5	3213 ± 9
	△	1759	3167
	◇	1738 ± 5	3128 ± 9
	●	1752	3153
	■	1758 ± 5	3164 ± 9
	▲	1760	3168
	▼	1769	3184
Heat of Fusion		**cal g^{-1}**	**Btu lb^{-1}**
	▽	92.5	166.5

PROPERTIES OF NIOBIUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-12	1713		99.9 Nb_2O_5.	M. P. from approx. fusion temperature during sintering.
□	53-11	1785		Nb_2O_5; 0.03 Si, 0.05> Mg, and 0.01> Ti.	Heated to 1650 C before testing; M. P. by visual observation.
▽	53-11	1785		Same as above.	Same as above except Δh_s from enthalpy difference above and below M. P.
△	55-31	1760		Nb_2O_5.	M. P. by thermal analysis.
◇	58-13	1733-1743		0.2> Ta_2O_5.	
●	62-18	1752		0.08 Zr, 0.01> Ta, 0.002> Ti, 0.04 Al, 0.001 Mn, 0.03 Fe, 0.04 Si, and 0.005 Mg.	Measured in air.
■	62-19	1753-1763		0.01> Si, 0.001> Mg, Au, Cu, Ta, and 0.01> Si, 0.001> Mg, As, Cr, Ta, and perhaps Ta repeated.	Same as above.
▲	61-28	1760		99.7 Nb_2O_5.	Same as above.
▼	60-23	1769		99.7* Nb_2O_5.	Same as above.



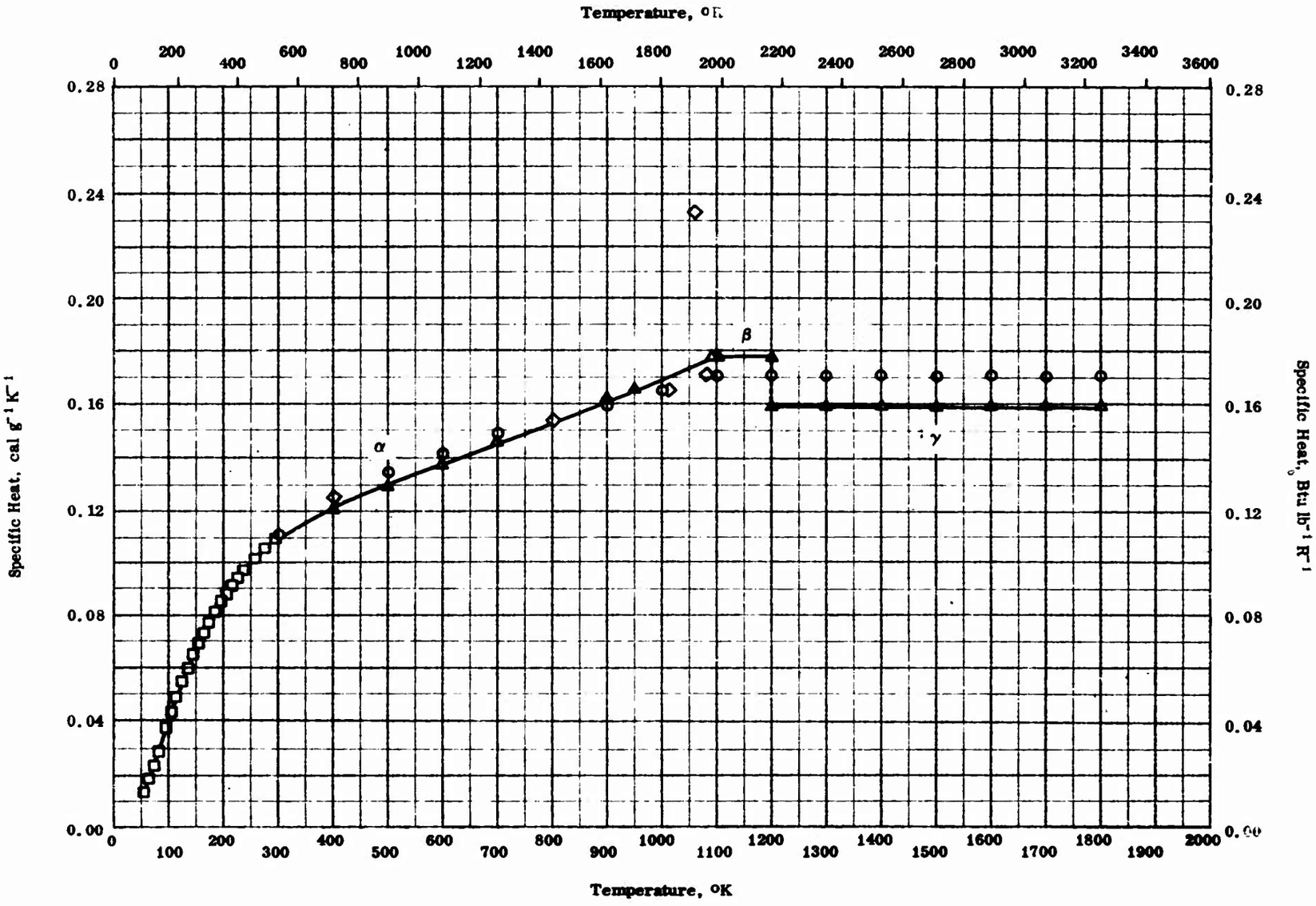
SPECIFIC HEAT -- NIOBIUM MONOXIDE

SPECIFIC HEAT -- NIOBIUM MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	60-7	300-1810		NbO; prepared synthetically from high purity Nb_2O_5, carbothermic Nb and carbon black.	

TPRC

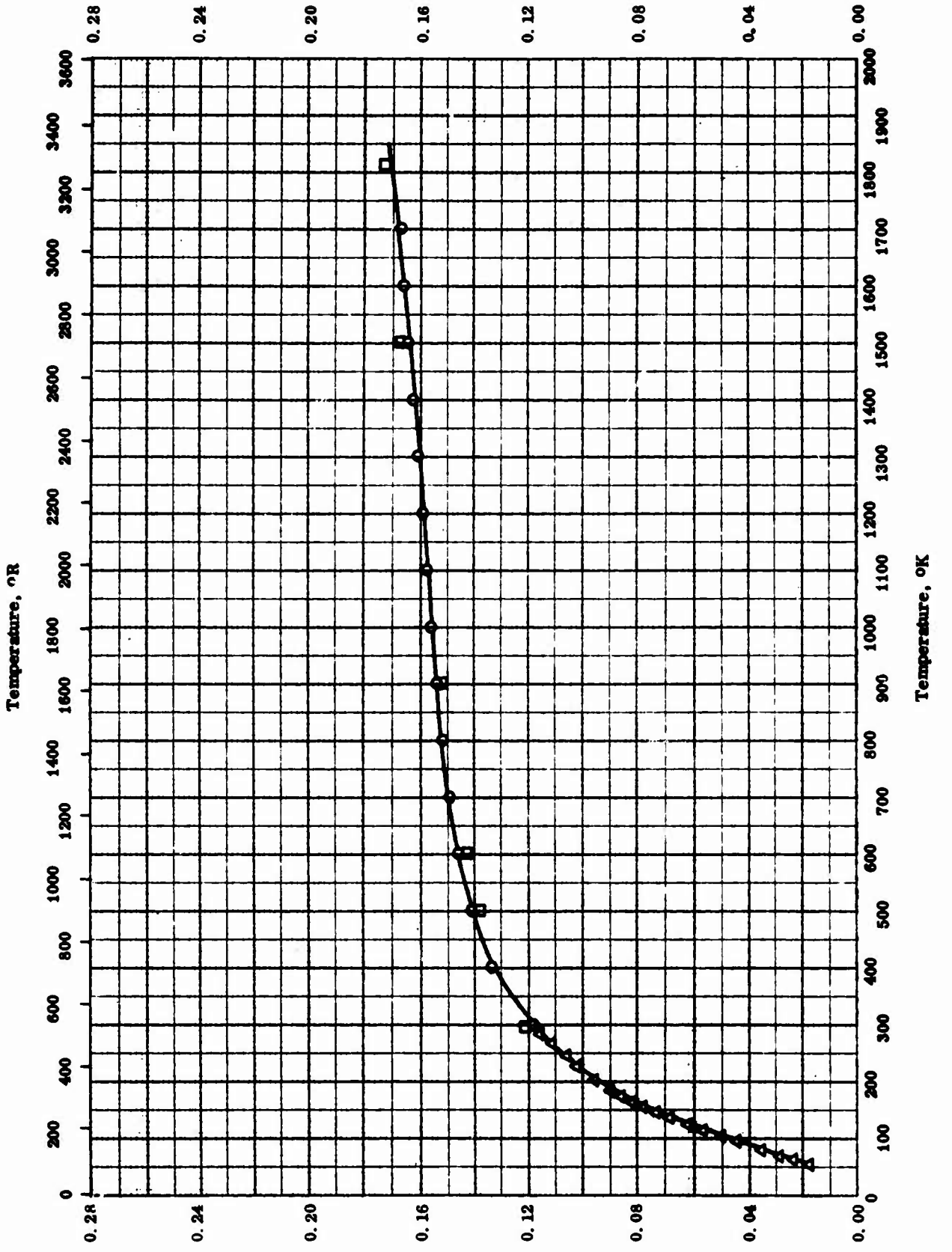


SPECIFIC HEAT -- NIOBIUM DIOXIDE

SPECIFIC HEAT -- NIOBIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	60-7	300-1800		NbO_2.	
□	58-9	53-298		99.9 NbO_2.	
△	61-14	298-1800	0.2	99.90 NbO_2.	Prepared by reduction of niobium pentoxide with hydrogen for 4 hrs at 950-1000 C and 4 hrs more treatment in hydrogen at 950-1000 C.
◇	60-13	298-1500		NbO_2 with 74.42 Nb.	



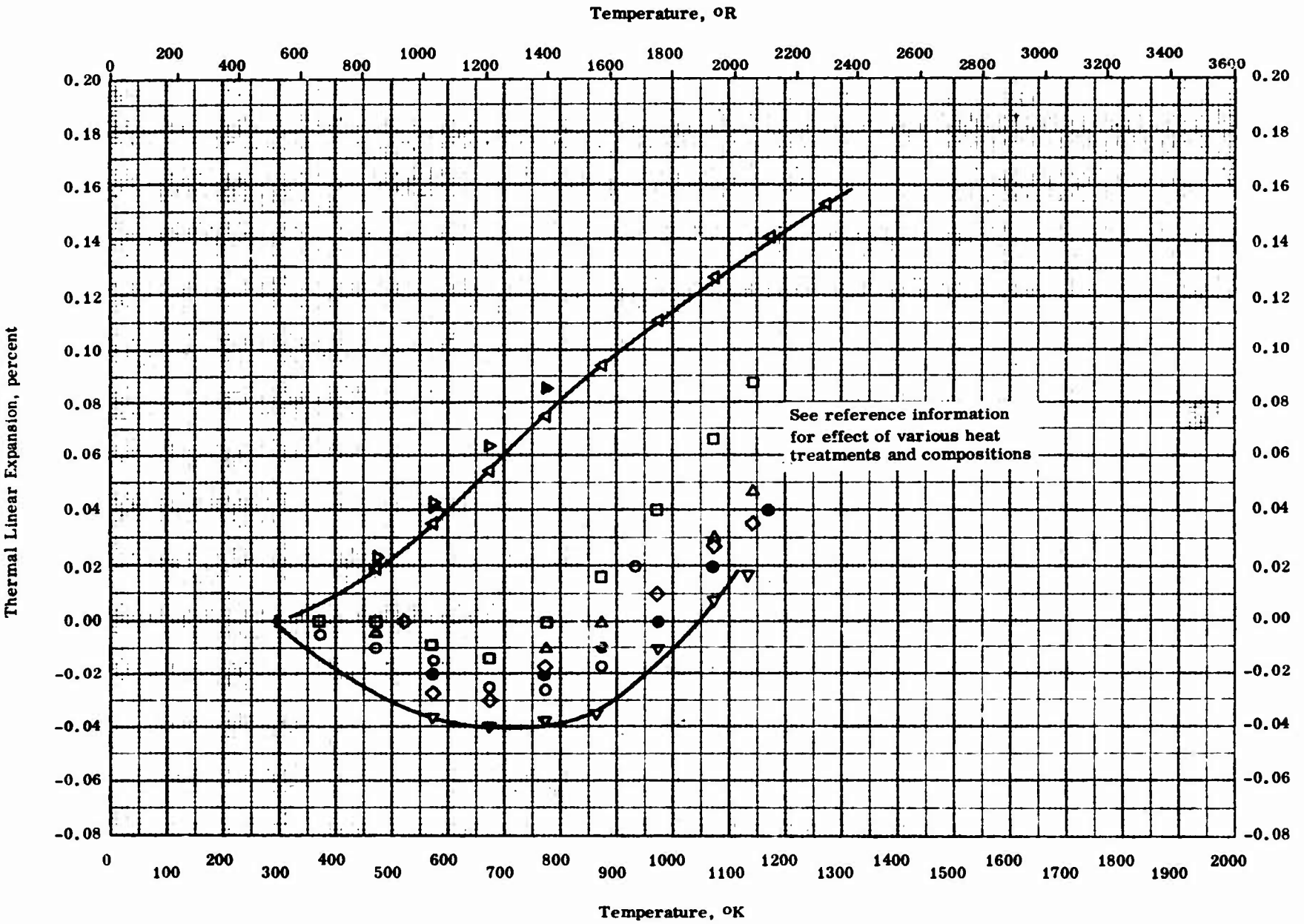
SPECIFIC HEAT -- NIOBIUM PENTOXIDE

SPECIFIC HEAT -- NIOBIUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	60-7	300-1700		Nb_2O_5.	
□	53-11	298-1810		Nb_2O_5; 0.05 > Mg, 0.03 Si, 0.01 > Ti.	Heated to 1050 C.
△	54-16	53-298		Nb_2O_5; 0.10 > impurities.	

TPRC



THERMAL LINEAR EXPANSION -- NIOBIUM PENTOXIDE

THERMAL LINEAR EXPANSION -- NIOBIUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◁	62-31	293-1273		Stoichiometric Nb_2O_5; prepared from 1.3 μ diameter, 99.96 Nb_2O_5 powder; dimensions 40 mm long by 2 mm square; density 4.55 g cm^{-3}.	Hot pressed in boron nitride-coated dies in a vacuum of 1 μ at 1300 C and 3000 psi for 30 min; sample held at constant temperature until movement ceased.
▷	62-31	293-773		$Nb_2O_{4.978}$; same as above.	Same as above except measured with heating rate of 10 C min^{-1}.
▶	62-31	293-773		Same as above.	Cooling cycle for above sample.
○	52-22	293-933		99.6 Nb_2O_5, remainder mostly Ta_2O_5; porosity 9.8 %; crystals medium coarse to coarse.	Wet milled for 20 hrs, dried, screened, pressed into compacts, calcined, crushed, screened, hydrostatically pressed at 100,000 psi, and fired in air at 1455 C.
□	52-12	293-1143		Nb_2O_5; prepared from - 200 mesh chemically pure Nb_2O_5 (99.9 Nb_2O_5) from A.D. McKay, Inc. containing less than 0.5 impurities.	Heated 2 hrs at 1315 C and furnace cooled.
△	52-12	293-1143		Same as above.	Heated 2 hrs at 1370 C and furnace cooled.
◇	52-12	293-1143		Same as above.	Heated 2 hrs at 1315 C and air quenched.
▽	52-12	293-1133		Same as above.	Heated 2 hrs at 1370 C and air quenched.
●	52-12	293-1173		Same as above.	Heated 2 hrs at 1370 C, furnace cooled, refired for 100 hrs at 1200 C, and furnace cooled.

PROPERTIES OF PLUTONIUM OXIDES

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	11.46	715
Melting Point	2553	4595
Heat of Sublimation	330_{1900K} *	590_{3400R} *

*For PuO only

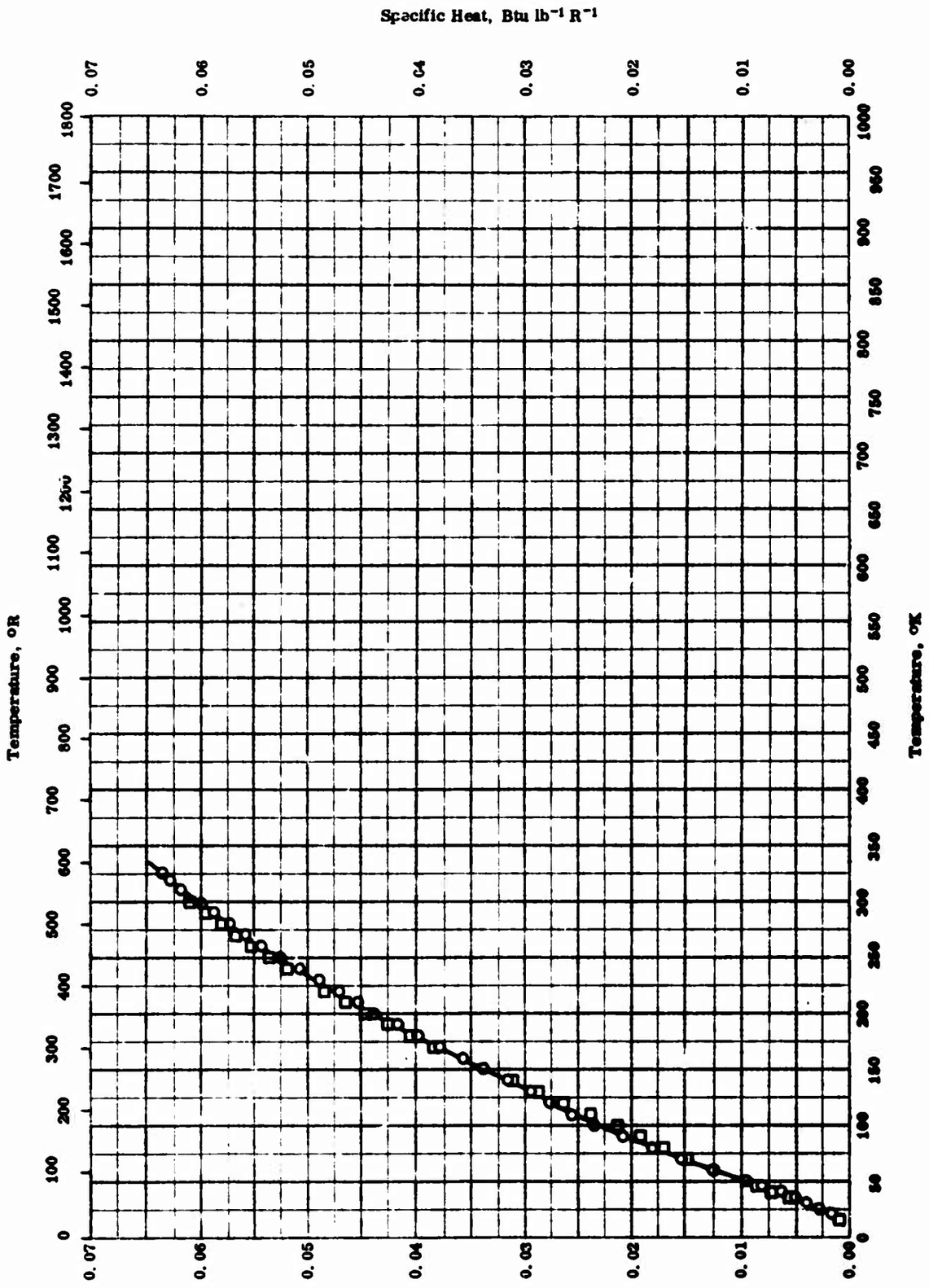
REPORTED VALUES

Density	g cm^{-3}	lb ft^{-3}
□ PuO_2	11.46	715
Melting Point	K	R
△ PuO_2	2553 ± 30	4595 ± 54
Heat of Sublimation	cal g^{-1}	Btu lb^{-1}
○ PuO	330_{1900K}	590_{3400R}

PROPERTIES OF PLUTONIUM OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	43-2	1673-2073		PuO.	Δh_s from vapor pressure data; author estimates that this value is too high, but of reasonable order of magnitude.
□	63-22	298		PuO_2 crystal.	Made by thermal decomposition in air of plutonium oxalate and of plutonium peroxide; fired at 950 C.
△	63-24	2523-2583		PuO_2.	Measured in He.



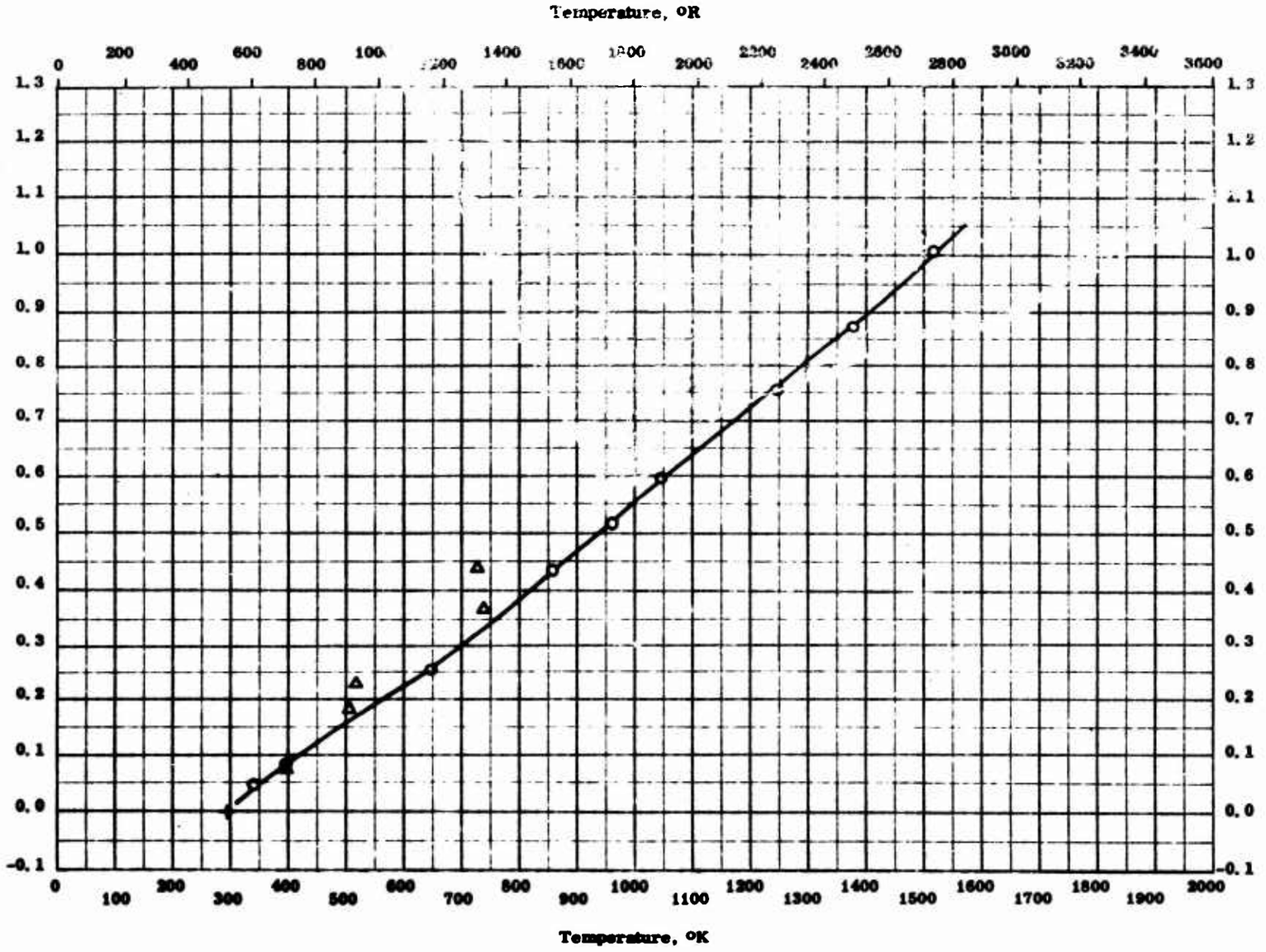
SPECIFIC HEAT -- PLUTONIUM DIOXIDE

SPECIFIC HEAT -- PLUTONIUM DIOXIDE

REFERENCE INFORMATION

Sym bol	Ref.	Temp. Range °K	Repd. Error %	Sample Specifications	Remarks
O	63-17	13-325		PuO_2; 87.30 Pu, 0.01 N, 0.008 Si, 0.004 C, 0.0040 Fe, 0.0020 > Cr, 0.0001 Cu, 0.0004 Mn, and 0.0043 other elements; after compressing twice in steel die; 0.3[illegible] Fe, 0.24 Ni, 0.055 Am, 0.0[illegible] N, 0.030 Mn, 0.0025 Cu, and 0.0196 other elements.	Pressed at 50,000 psi in four wafers and fired in air at 1650 -1700 C for 5 hrs.
□	62-12	10-320		Same as above.	Same as above.

TPRC

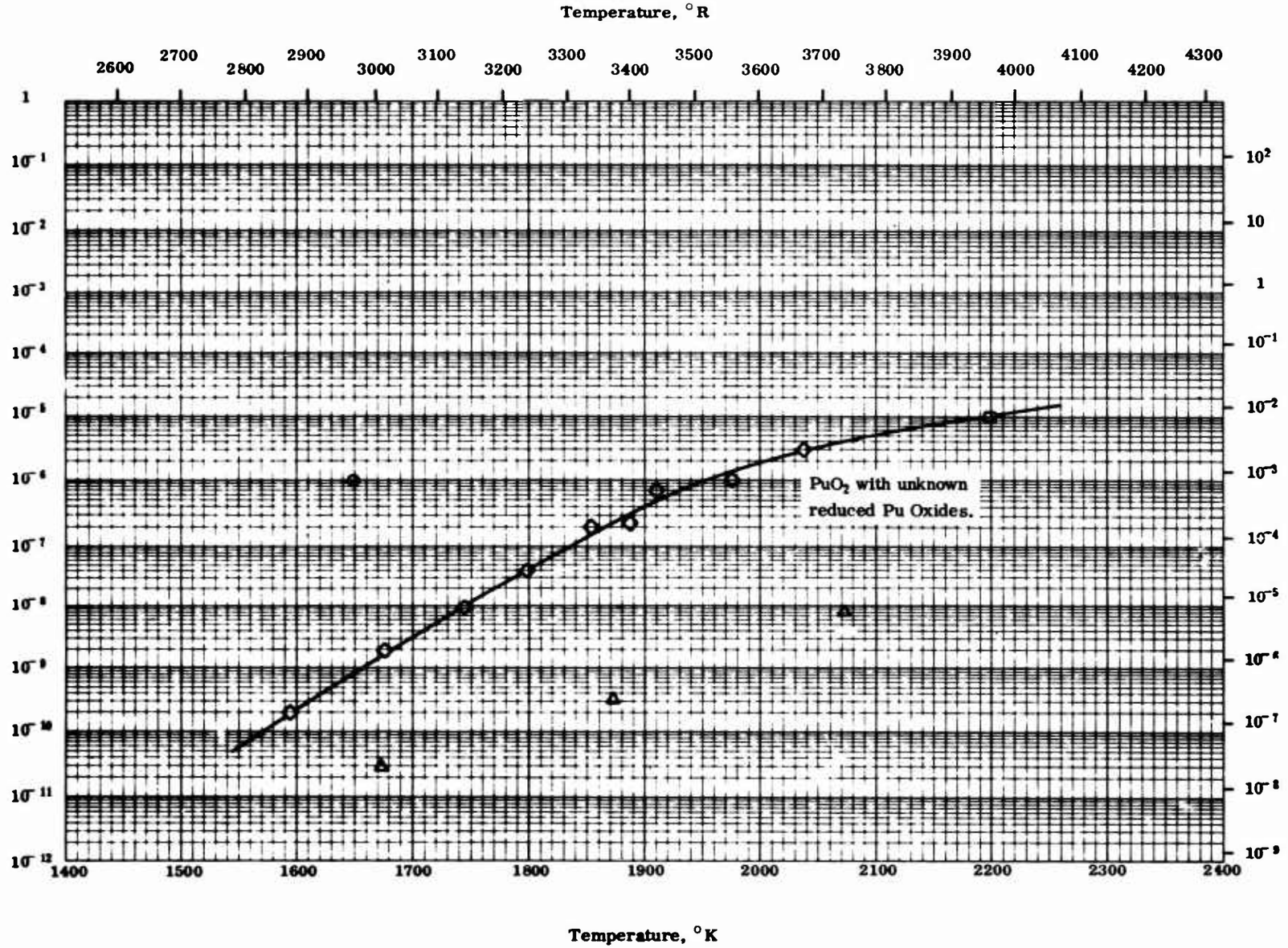


THERMAL LINEAR EXPANSION -- PLUTONIUM DIOXIDE

THERMAL LINEAR EXPANSION -- PLUTONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-40	304-1513		PuO_2.	Percent expansion calculated from a_o lattice parameters.
Δ	57-38	293-739		PuO_2.	Authors consider values to be of limited accuracy; x-ray method.



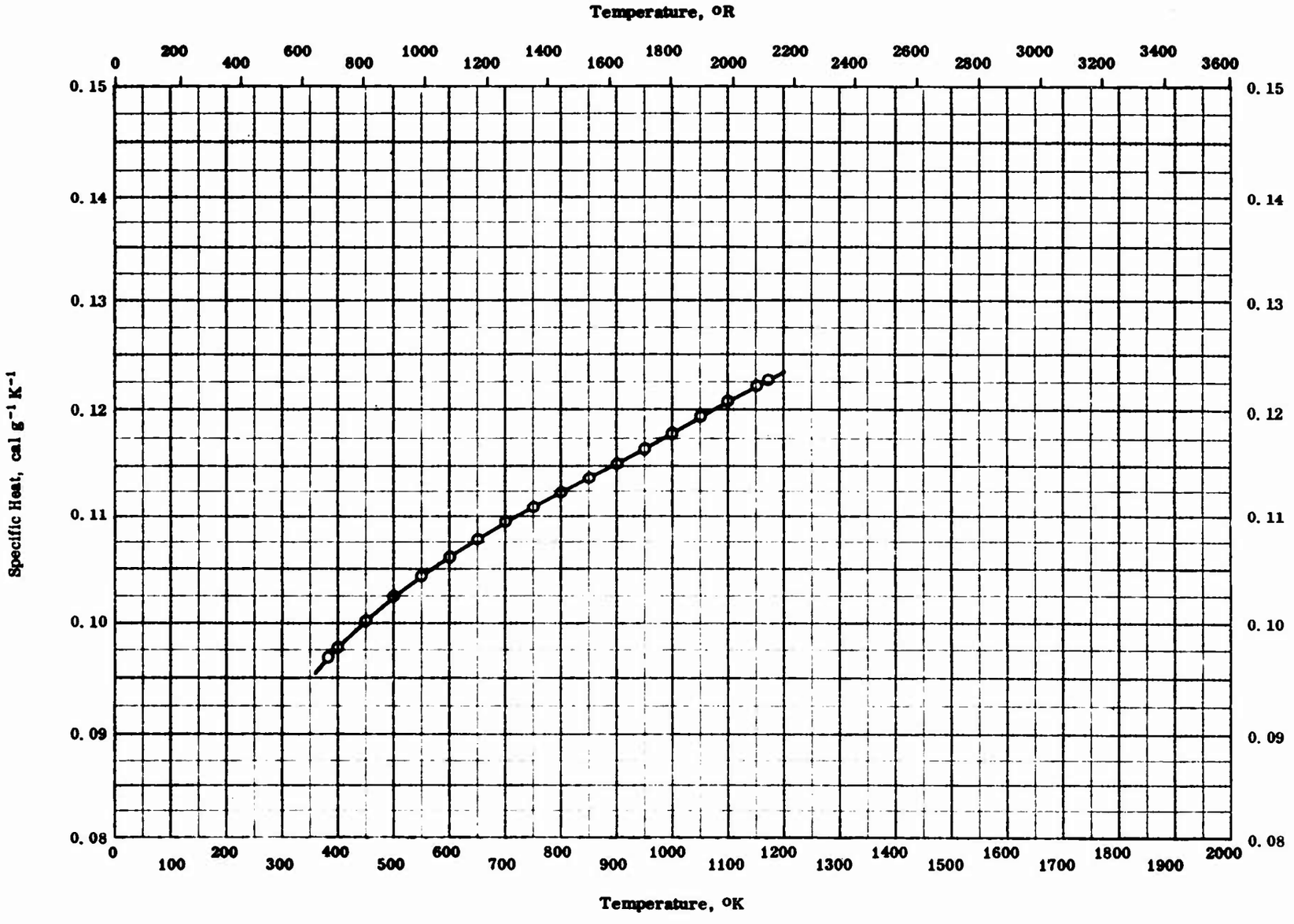
TPRC

VAPOR PRESSURE -- PLUTONIUM OXIDES

VAPOR PRESSURE -- PLUTONIUM OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	49-2	1650		PuO.	
□	49-2	2200		PuO_2.	Estimate from corresponding uranium compound.
△	43-2	1673-2073		Pu Oxide.	Author est. only order of magnitude.
◇	50-3	1590-2060		PuO_2 with unknown reduced Pu Oxide.	



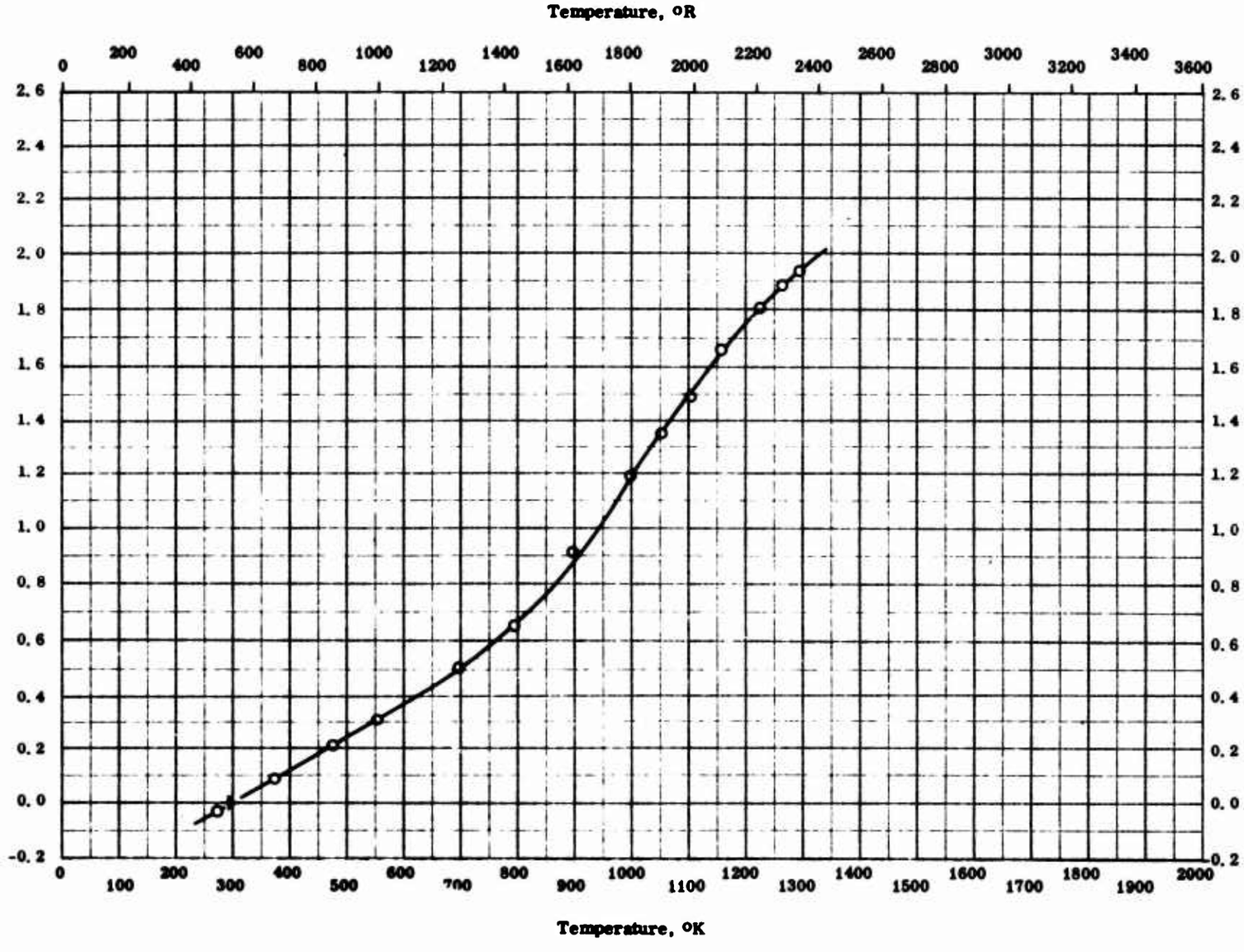
TPRC

SPECIFIC HEAT -- PRASEODYMIUM OXIDE

SPECIFIC HEAT -- PRASEODYMIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	51-7	383-1171	0.4	99.5 Pr_6O_{11}.	

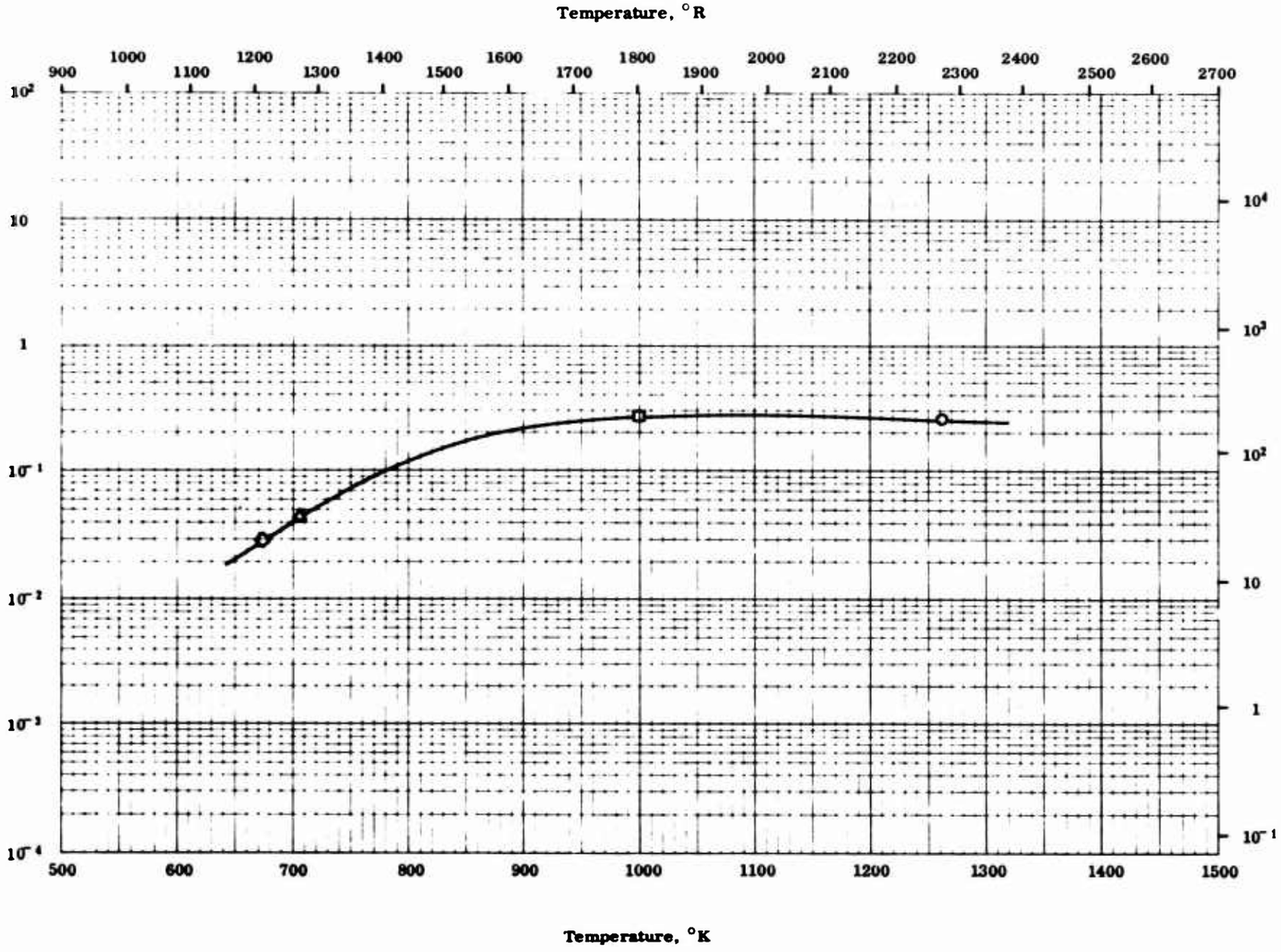


THERMAL LINEAR EXPANSION -- PRASEODYMIUM OXIDE

THERMAL LINEAR EXPANSION -- PRASEODYMIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	61-41	273-1293	1.1-6.0	Pr_6O_{11}, code 729.9 from Lindsay Chemical Co., West Chicago, Ill.; 99.9 Pr_6O_{11} in regard to total rare-earth content; 0.003-0.03 Ca and trace of Fe, Mg, and Si.	Sintered at 950 C for 24 hrs, packed into alumina sample holder, resintered at 1050 C for 12 hrs, cooled to 300 C, and placed in a vacuum desiccator for storage; x-ray diffractometer method.



VAPOR PRESSURE -- PRASEODYMIUM OXIDE

VAPOR PRESSURE -- PRASEODYMIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	55-12	673-1273		$PrO_{1.709}$; body centered cubic phase.	Determined by x-ray photograph.
□	55-12	673-1273		$PrO_{1.717}$; rhombohedral phase.	Determined by x-ray photograph.
△	55-12	673-1273		$PrO_{1.804}$; face centered cubic phase.	Determined by x-ray photograph.
◇	55-12	673-1273		$PrO_{1.833}$; same as above.	Same as above.

PROPERTIES OF PROTACTINIUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	13.43	838.4

REPORTED VALUES

Density	$g\ cm^{-3}$	$lb\ ft^{-3}$
	o 13.43	°38.4

PROPERTIES OF PROTACTINIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	51-16	298		PaO.	Density computed from x-ray measurements of lattice.

PROPERTIES OF SAMARIUM SESQUIOXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density	7.4*	460*
Melting Point	2620*	4720*

*For Sm_2O_3 only.

REPORTED VALUES

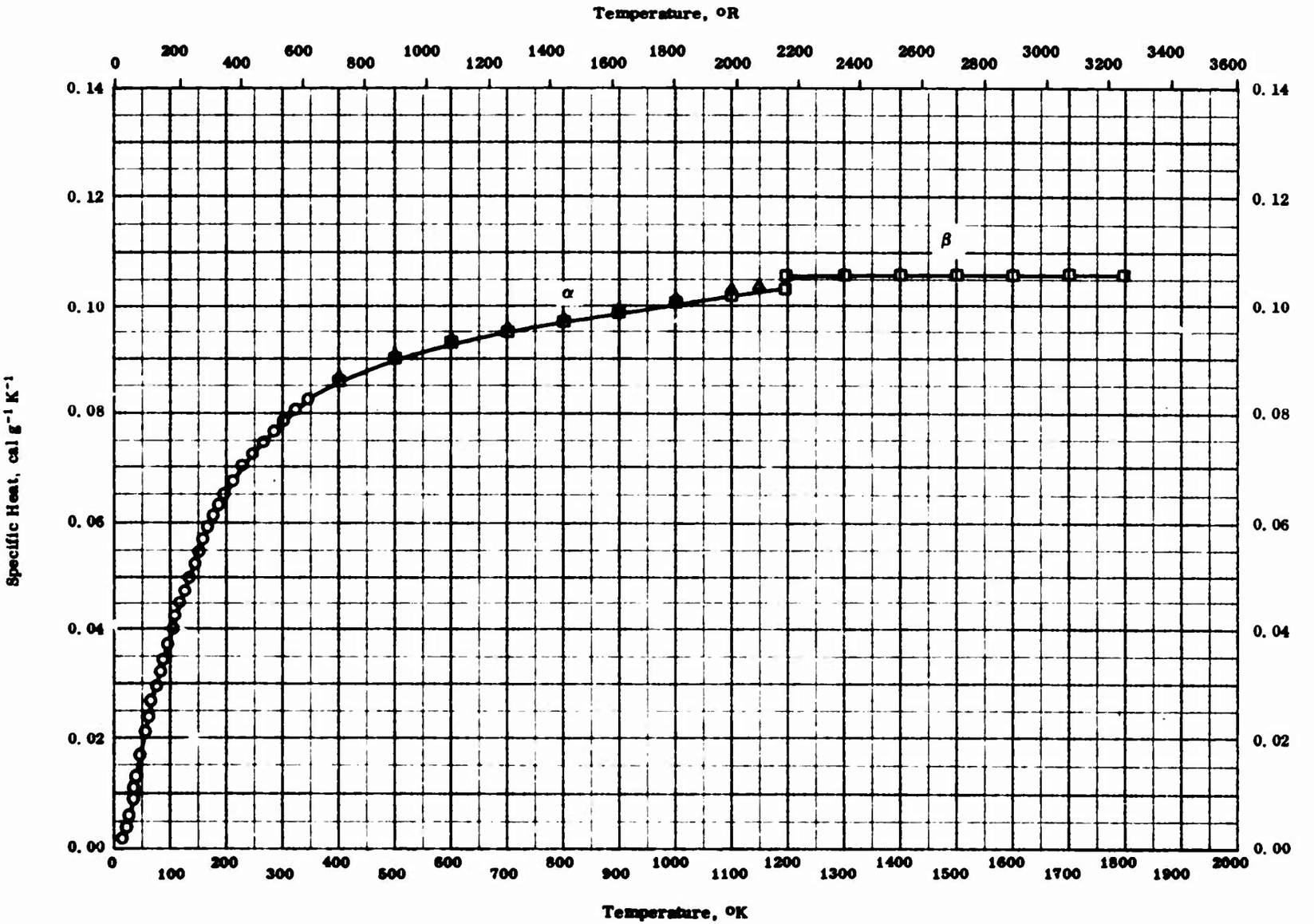
		$g\ cm^{-3}$	$lb\ ft^{-3}$
Density			
	□	6.0	375
	△	7.4	462
	▽	7.74	483.0
	◁	7.62	475.5

		K	R
Melting Point			
	○	2623 ± 50	4722 ± 90
	◇	2573 ± 50	4632 ± 90

PROPERTIES OF SAMARIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	57-8	2573-2673		Sm_2O_3; 0.5 > Nd, 0.4 Eu, 0.3 > Gd, 0.2 > each Dy, Ho, and Pr, 0.1 > Tb, and 0.05 > each Y, La, Er, Yb.	M.P. by observing first liquid drop.
□	57-8	298		Same as above.	Pressed at 2700 psi and fired 2 hrs at 1300 C.
△	57-8	298		Same as above.	Same as above; sintered and cracked.
◇	56-22	2523-2623		Sm_2O_3.	M.P. by observing first liquid drop on V-shaped ribbon.
▽	62-16	298		Sm_2O_3 - B.	
◁	62-16	298		Sm_2O_3 - C.	

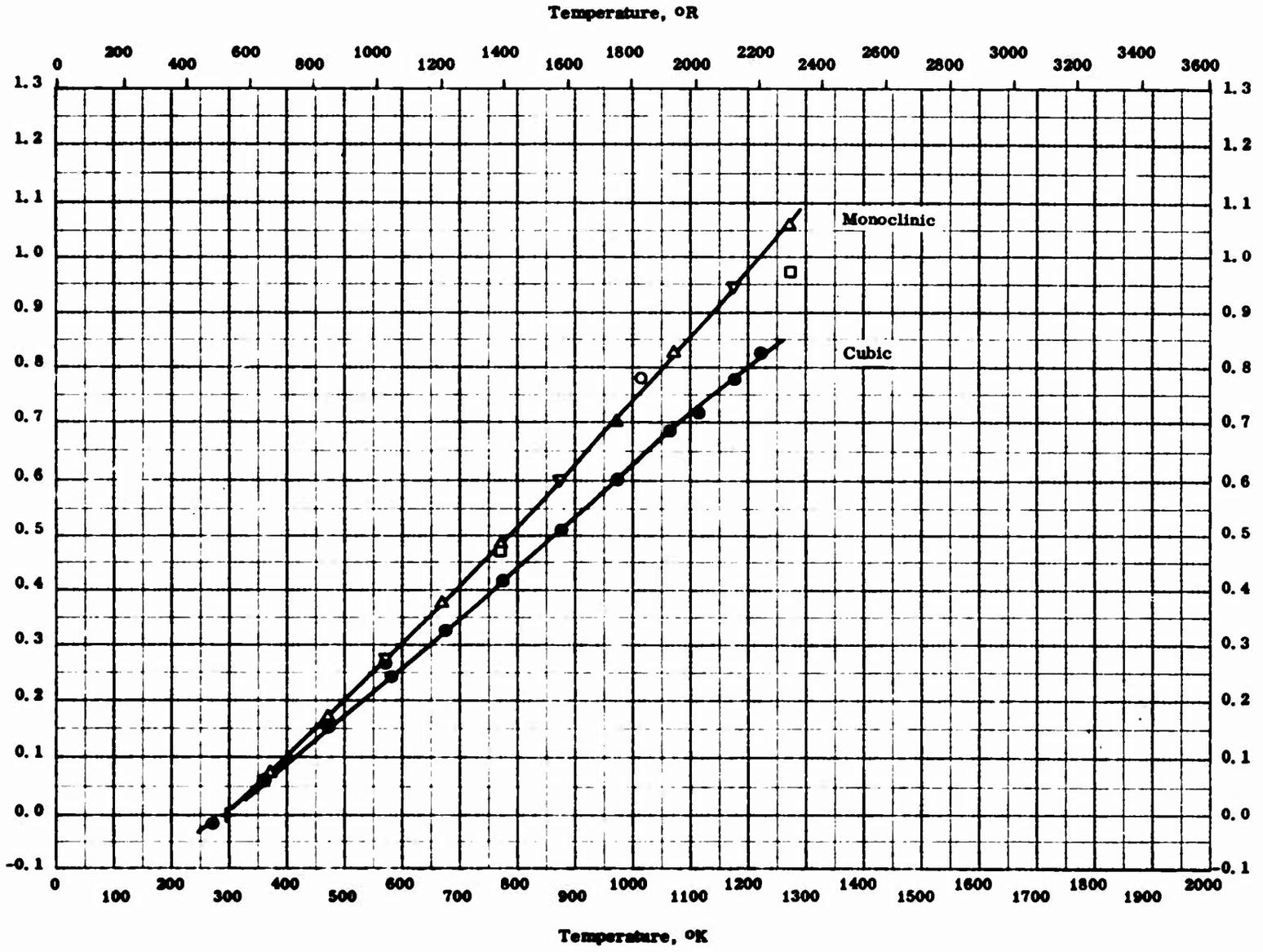


SPECIFIC HEAT -- SAMARIUM SESQUIOXIDE

SPECIFIC HEAT -- SAMARIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	61-13 also 60-12	5-347	0.1	99.9 Sm_2O_3, 0.0350 Ca, 0.020 Si, and 0.010 Eu.	Pelleted under 2000–4000 psi and fired at 1170 K; measured under helium.
□	62-11	298-1798	0.2	99.9 Sm_2O_3; monoclinic structure.	Measured under helium.
Δ	62-11	298-1149	0.2	99.9 Sm_2O_3; cubic structure.	Same as above.

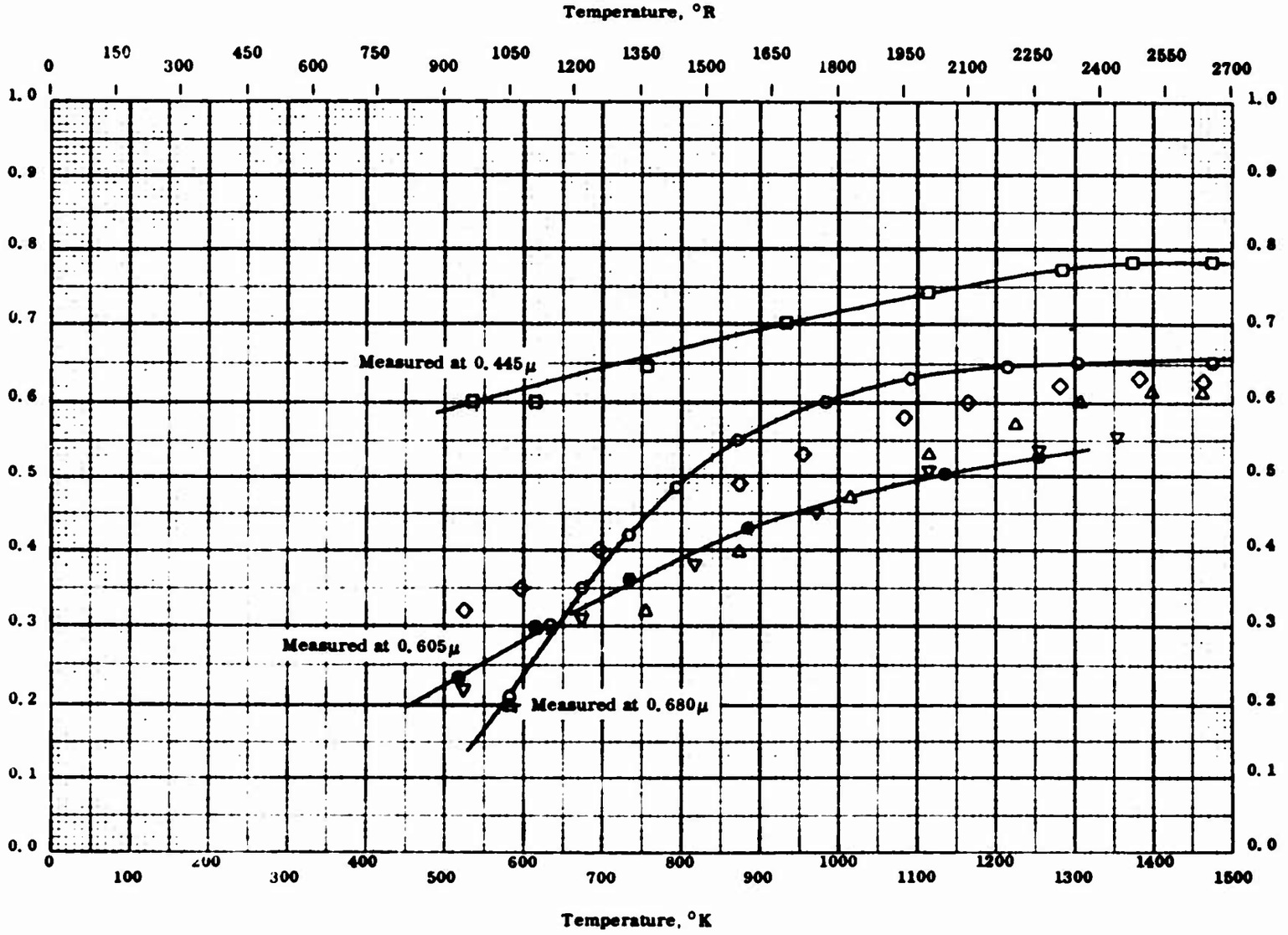


THERMAL LINEAR EXPANSION -- SAMARIUM SESQUIOXIDE

THERMAL LINEAR EXPANSION -- SAMARIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error σ_r	Sample Specifications	Remarks
●	61-41	273-1223	1.1-6.0	Sm_2O_3, code 823 from Lindsay Chemical Co., West Chicago, Ill.; 99.9 Sm_2O_3 in regard to rare-earth content: 0.01 - 0.1 Ca and Eu, 0.001 - 0.01 Si, and 0.0003 - 0.003 Mg; cubic, rare-earth oxide type C.	Sintered at 850 C for 24 hrs, packed in alumina sample holder, resintered at 900 C for 24 hrs, cooled to 300 C, and placed in a vacuum desiccator for storage; x-ray diffractometer method.
△	63-35	298-1273		Sm_2O_3; 0.03 - 0.3 Ca and Eu, 0.003 - 0.03 Si, and 0.001 - 0.01 Mg; monoclinic; bulk density after expansion run by mercury displacement at low pressure 7.3 g cm^{-3}.	Calcined at 1500 C for 1 hr, mixed with binder (2% Varsol plus 2% paraffin dissolved in benzene), hot pressed at approx. 2600 psi to 1400 C, ground into shape, matured at 1500 C for approx. 1 hr, reground, heated to 1500 C for 1 hr, and desiccated; heating rate approx. 5 C min^{-1}.
▽	63-35	298-1276		Same as above.	Second run for above sample.
○	57-37	293-1013		Sm_2O_3.	Hot pressed at 1800 C in graphite mold to 95% of theoretical density.
□	57-8	293-1273		Sm_2O_3; < 0.5 Nd, < 0.4 Eu, < 0.3 Gd, and < 0.2 each Dy, Ho, and Pr.	Pressed at 2700 psi and fired 2 hrs at 1500 C; sintering and cracking noted at 1500 C.



TPRC

NORMAL SPECTRAL EMITTANCE -- SAMARIUM SESQUIOXIDE

NORMAL SPECTRAL EMITTANCE -- SAMARIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Wavelength μ	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	63-25	0.445	533-1473		Sm_2O_3.	Powdered material compressed to 75000 psi, fired at 1773 K for 24 hrs; ground to 0.125 in. thickness; measured in air; calculated from reflectance data; data taken from smooth curve.
◇	63-25	0.488	523-1463		Same as above.	Same as above.
△	63-25	0.533	583-1523		Same as above.	Same as above.
▽	63-25	0.570	523-1353		Same as above.	Same as above.
●	63-25	0.605	517-1263		Same as above.	Same as above.
○	63-25	0.680	583-1473		Same as above.	Same as above.

PROPERTIES OF SCANDIUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	3.59	224.0
Melting Point	2678	4820

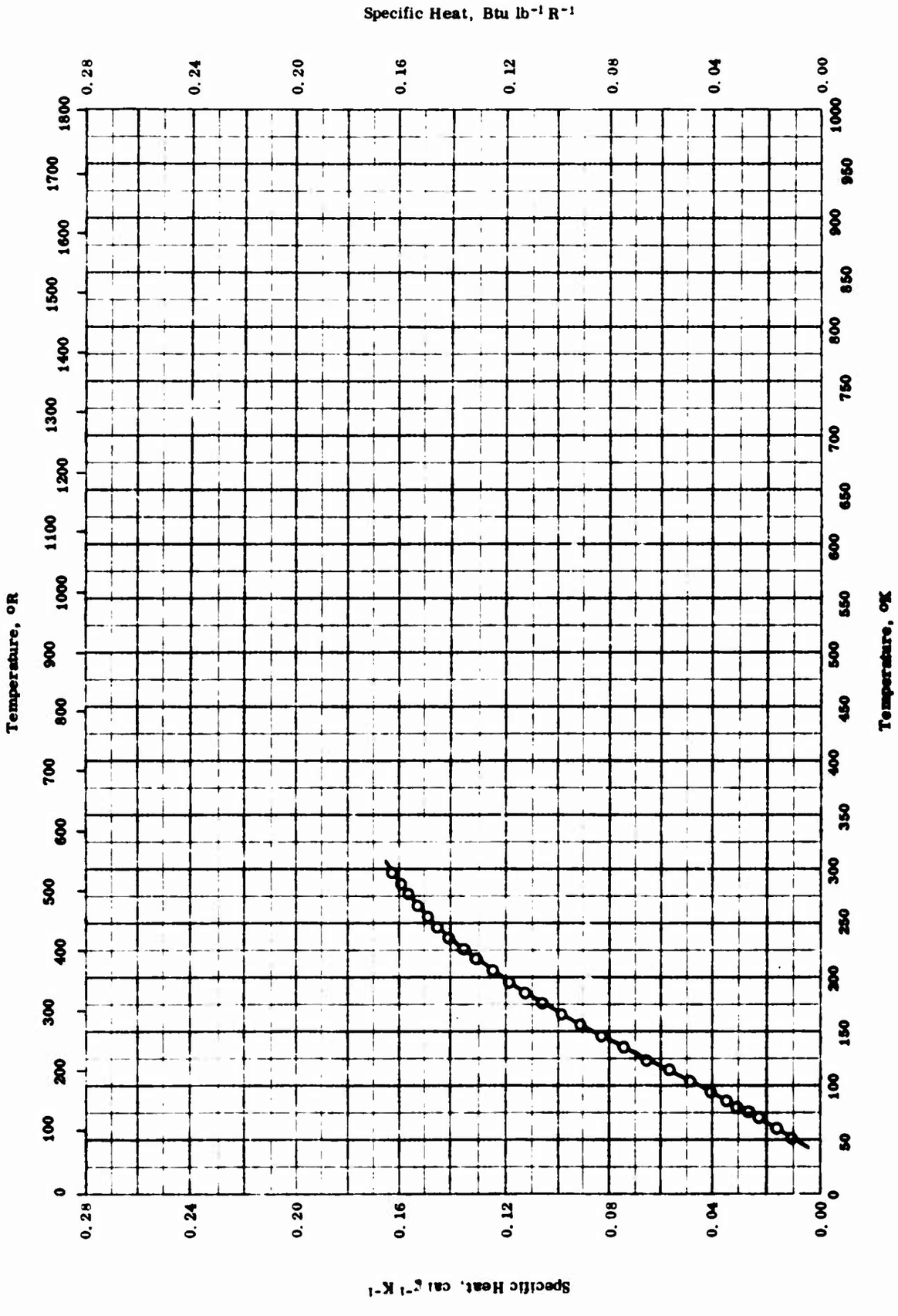
REPORTED VALUES

Density		$g\ cm^{-3}$	$lb\ ft^{-3}$
	○	3.59	224.0
Melting Point		K	R
	□	<2678	<4820

PROPERTIES OF SCANDIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-16	298		Sc_2O_3.	
□	63-23	< 2678		99.9 Sc_2O_3.	Measured in air.

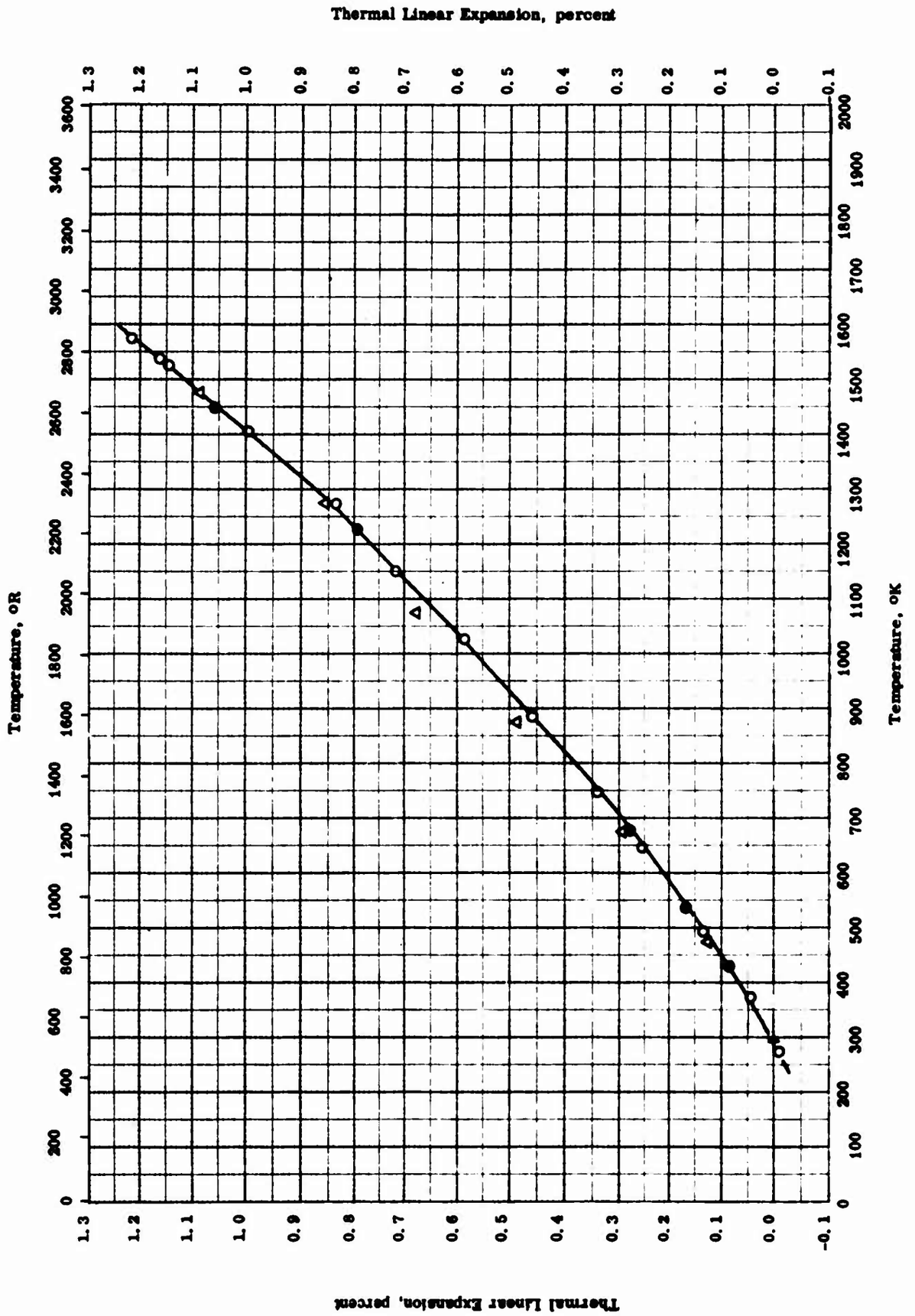


SPECIFIC HEAT -- SCANDIUM OXIDE

SPECIFIC HEAT -- SCANDIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-20	53-296	0.10	99.9 Sc_2O_3.	Measured in nitrogen.



THERMAL LINEAR EXPANSION -- SCANDIUM OXIDE

THERMAL LINEAR EXPANSION -- SCANDIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	61-41	273-1573		Sc_2O_3 from Heavy Minerals Co., Chattanooga, Tenn.; 99.5 Sc_2O_3 in regard to total rare-earth content; 0.01-0.1 each Al, La, Tm, and Yb, 0.003-0.03 each Ca and Zr, and trace of B, Cr, Cu, Fe, Ho, Mg, Mn and Y; cubic, rare-earth oxide type C.	Sintered at 1150 C for 24 hrs, packed into alumina sample holder, resintered at 1200 C, cooled to 300 C, and placed in a vacuum desiccator for storage; x-ray diffractometer method.
●	61-41	430-1573		Same as above.	Cooling cycle for above sample.
△	61-44	298-1473		>99 pure Sc_2O_3 from Research Chemicals Inc., Burbank, Calif.	X-ray method.

TPRC

PROPERTIES OF SILICON DIOXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	2.65	166
Melting Point	1708	3074

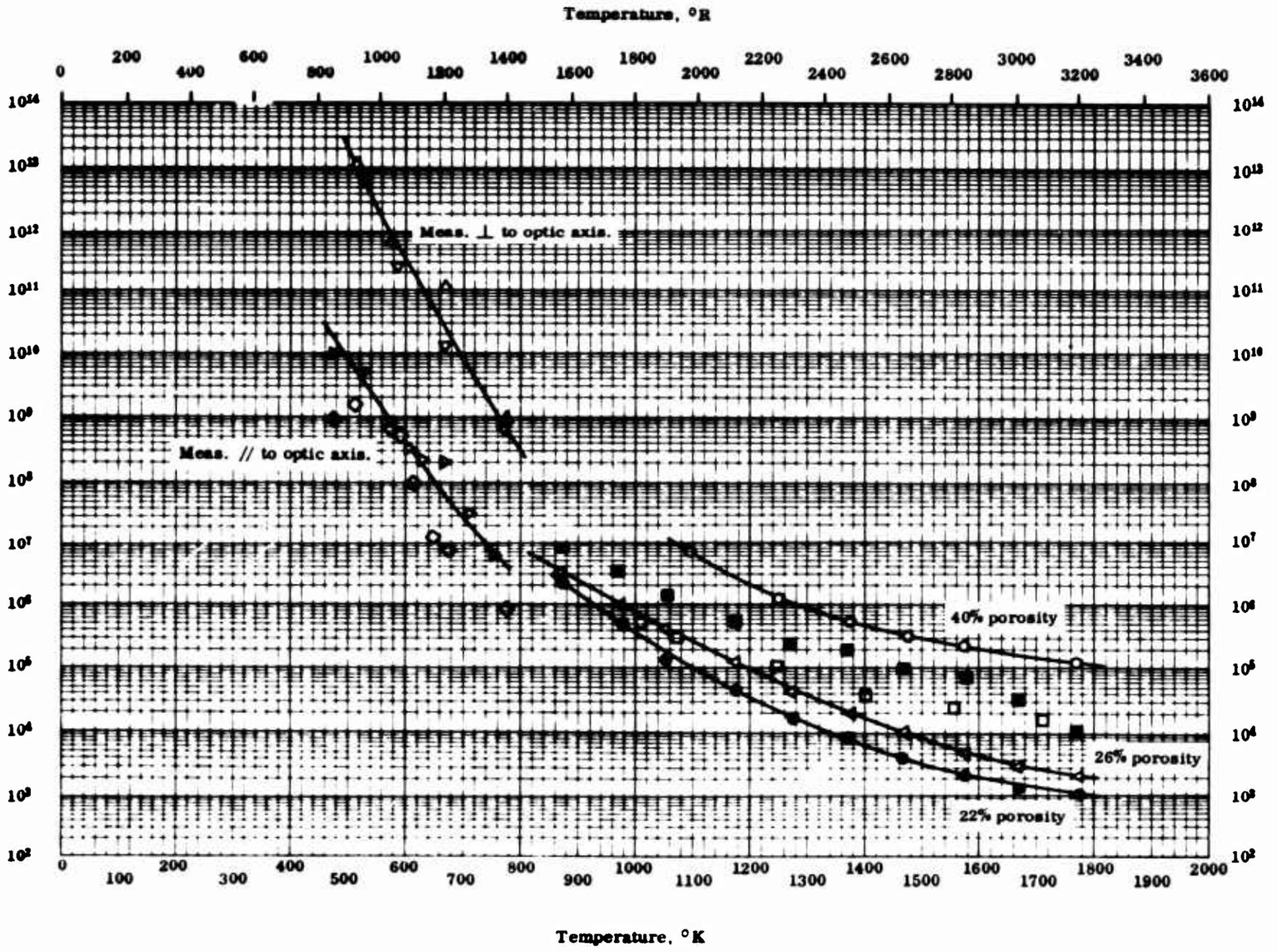
REPORTED VALUES

		$g\ cm^{-3}$	$lb\ ft^{-3}$
Density			
	○	2.545	158.9
	□	2.298	143.4
	△	2.604	162.5
	▽	2.301	143.6
	◁	2.609	162.9
	▷	2.324	145.1
	◇	2.615	163.3
	●	2.290	142.9
	■	2.65 ±0.06	165 ±4
		K	**R**
Melting Point			
	▲	1708	3074

PROPERTIES OF SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	55-28	298		Silica rock; 98.35 SiO_2, 0.52 Al_2O_3, 0.43 Fe_2O_3, 0.28 MgO, and 0.05 CaO.	Fired 3 hrs at 1400 C in air; density by pycnometer
□	55-28	298		Same as above.	Fired 4 hrs at 1330 C in air; same as above.
△	55-28	298		Same as above.	Fired 3 hrs at 1298 C in water vapor; same as above.
◁	55-28	298		Silica rock; 99.72 SiO_2, 0.14 Fe_2O_3, and 0.10 CaO.	Fired 5-1/2 hrs at 1448 C in air; same as above.
▷	55-28	298		Same as above.	Fired 4 hrs at 1650 C in air; same as above.
▽	55-28	298		Silica rock; 98.35 SiO_2, 0.52 Al_2O_3, 0.43 Fe_2O_3, 0.28 MgO, and 0.05 CaO.	Fired 4 hrs at 1540 C in air; same as above.
◇	55-28	298		Silica rock; 99.13 SiO_2, 0.63 Fe_2O_3, 0.11 Alkalis, 0.09 CaO, 0.01 MgO, and 0.01 Al_2O_3.	Fired 3-5/60 hrs at 1240 C in air; same as above.
●	55-28	298		Same as above.	Fired 4 hrs at 1537 C in air; same as above.
■	57-13	298		Brazilian quartz.	Density by weight in air and in kerosene.
▲	60-25	1683-1723		Quartz; 0.1 >Cs, 0.001 ≥ Li, Na, Ca, Pt, Pb, Sn, Fe, and B, and 0.01 >K, Rb, Sr, Ba, and Al.	



ELECTRICAL RESISTIVITY -- SILICON DIOXIDE

ELECTRICAL RESISTIVITY -- SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-17	1093-1763		100 SiO_2; 40% porosity.	Fired 10 hrs at 1500 C.
□	53-17	1013-1713		Same as above.	Fired 24 hrs at 1450 C.
△	53-18	517-773		Quartz crystal.	Parallel to optic axis.
◇	53-18	473-773		Same as above.	Perpendicular to optic axis.
▽	56-12	526-770		Impurities 0.01-~1 Al, 0.001-0.01 ea. Fe, Mg, Na, and 0.0001-0.001 ea. Cr, Ca, Cu.	Perpendicular to optic axis.
▷	56-12	476-755		Same as above.	Parallel to optic axis.
◁	53-16	873-1773		Super duty silica; 97 SiO_2; commercial refractory; 26% porosity.	
●	53-16	873-1773		Standard silica; 96 SiO_2; commercial refractory; 22% porosity.	
■	53-16	873-1773		92 SiO_2, pyrometric cone equivalent less than standard, commercial refractory; 27% porosity.	

TPRC

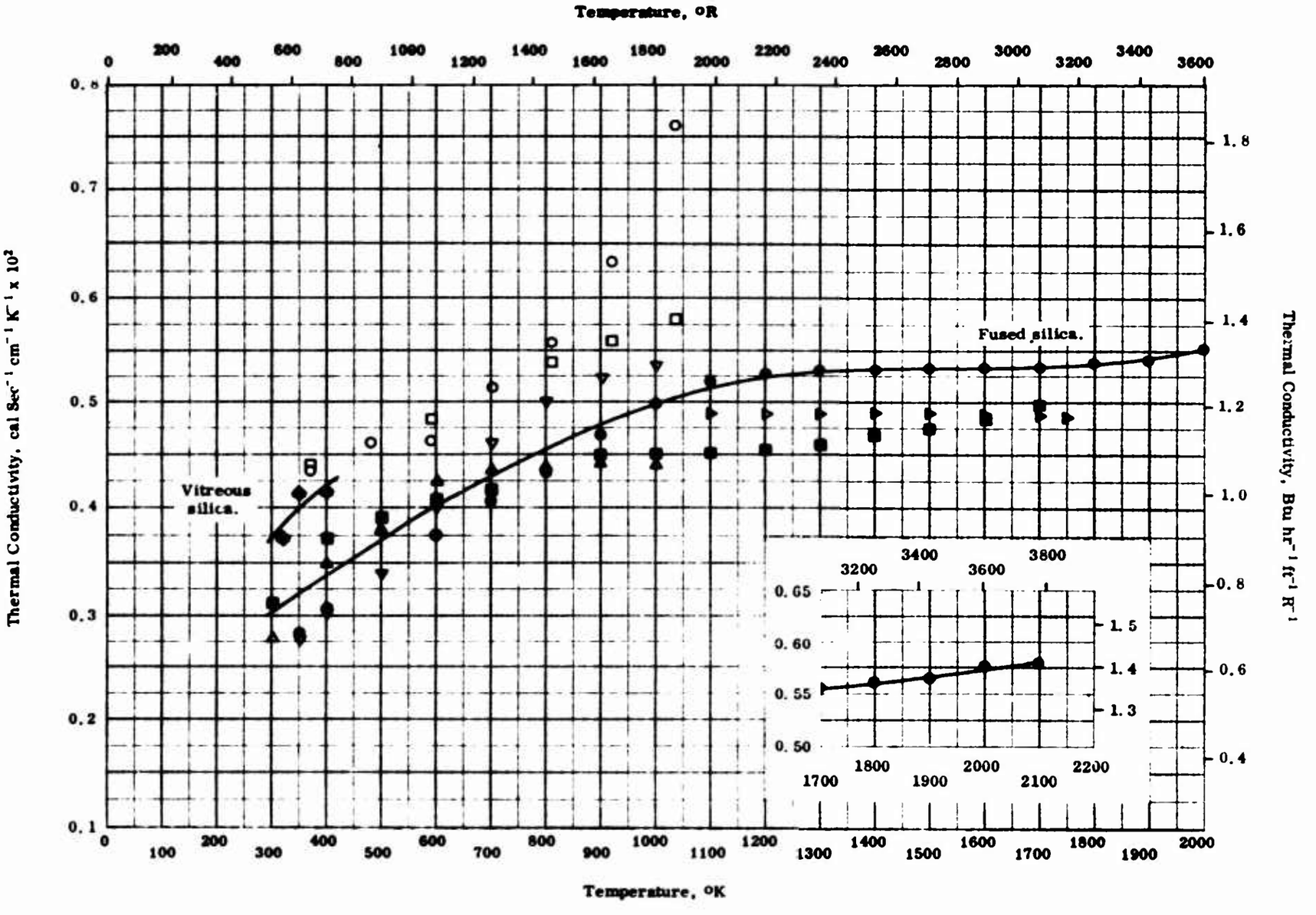
SPECIFIC HEAT -- SILICON DIOXIDE

SPECIFIC HEAT -- SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	36-1	317-950		Quartz crystal; transparent without blemish.	
△	53-14	303-922		Quartz crystal.	
□	55-16	353-673	8.0	Special high purity North Carolina crushed vein quartz; 40-60 mesh powder.	
◇	41-2	298-1520	0.4	99.95 SiO_2 and 0.05 residue.	Prepared from transparent vitreosil glass tubing by crushing and screening out fines.

TPRC

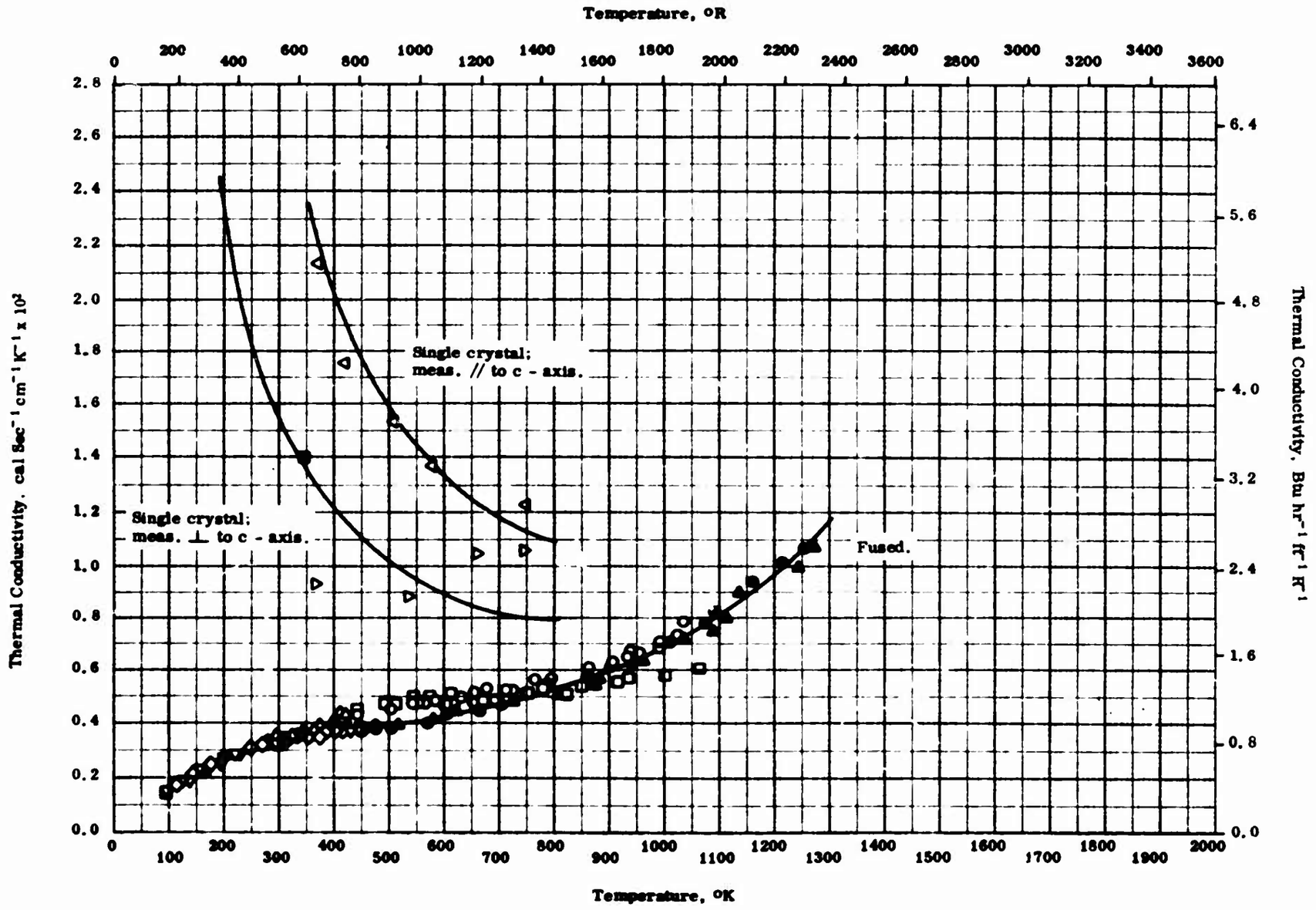


THERMAL CONDUCTIVITY -- SILICON DIOXIDE

THERMAL CONDUCTIVITY -- SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	60-1	367-1033		Clear fused silica from Hanovia Chem. Co.; density 0.07959 lb in^{-3} at 32 F.	
□	60-1	367-1033		Same as above.	Low emissivity Al foil discs placed adjacent to the sample surface.
△	59-3	300-1000		Clear fused silica; 0.549 cm dia and 10.20 cm long.	
▽	59-3	350-1000		Same as above.	Third run of the above sample.
▷	59-3	1100-1750		Same as above.	Fourth run of the above sample.
●	59-3	350-2100		Same as above; 0.478 cm dia and 8.30 cm long.	
■	59-3	300-1700		Same as above; 0.598 cm dia and 5.34 cm long.	
▲	52-4	319-398	± 3	Clear vitreous silica.	
◇	52-4	317-398	± 3	Smoky vitreous silica.	

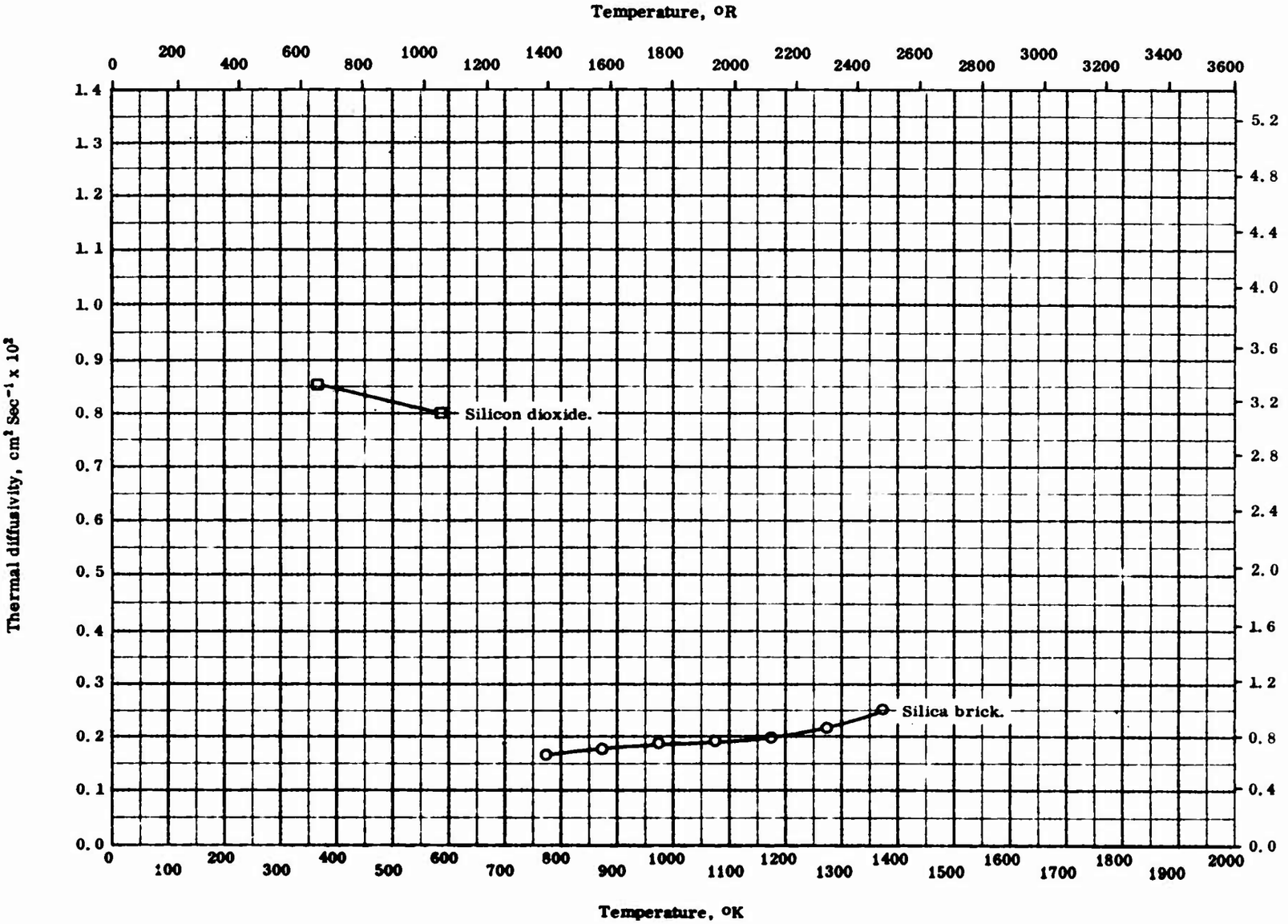


THERMAL CONDUCTIVITY -- SILICON DIOXIDE
(Quartz)

THERMAL CONDUCTIVITY -- SILICON DIOXIDE
(Quartz)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◁	43-1	370-748		Single crystal.	Parallel to c-axis.
▷	43-1	370-748		Single crystal.	Perpendicular to c-axis.
◧	53-2	343	±3	Single crystal.	Measured perpendicular to c-axis.
△	62-3	297-422			
◇	63-7	116-474	1-3	Fused quartz.	
▽	63-7	94-463	1-3	Fused quartz.	
■	63-7	96-305	1-3	Fused quartz.	
○	54-4	441-1037		Clear fused quartz.	
□	54-4	445-1065		Same as above.	The above sample; measured with low emissivity foil adjacent to the surface.
●	53-7	418-1253		Fused quartz.	First run.
▲	53-7	343-1273		Same as above.	Same as above; second run.

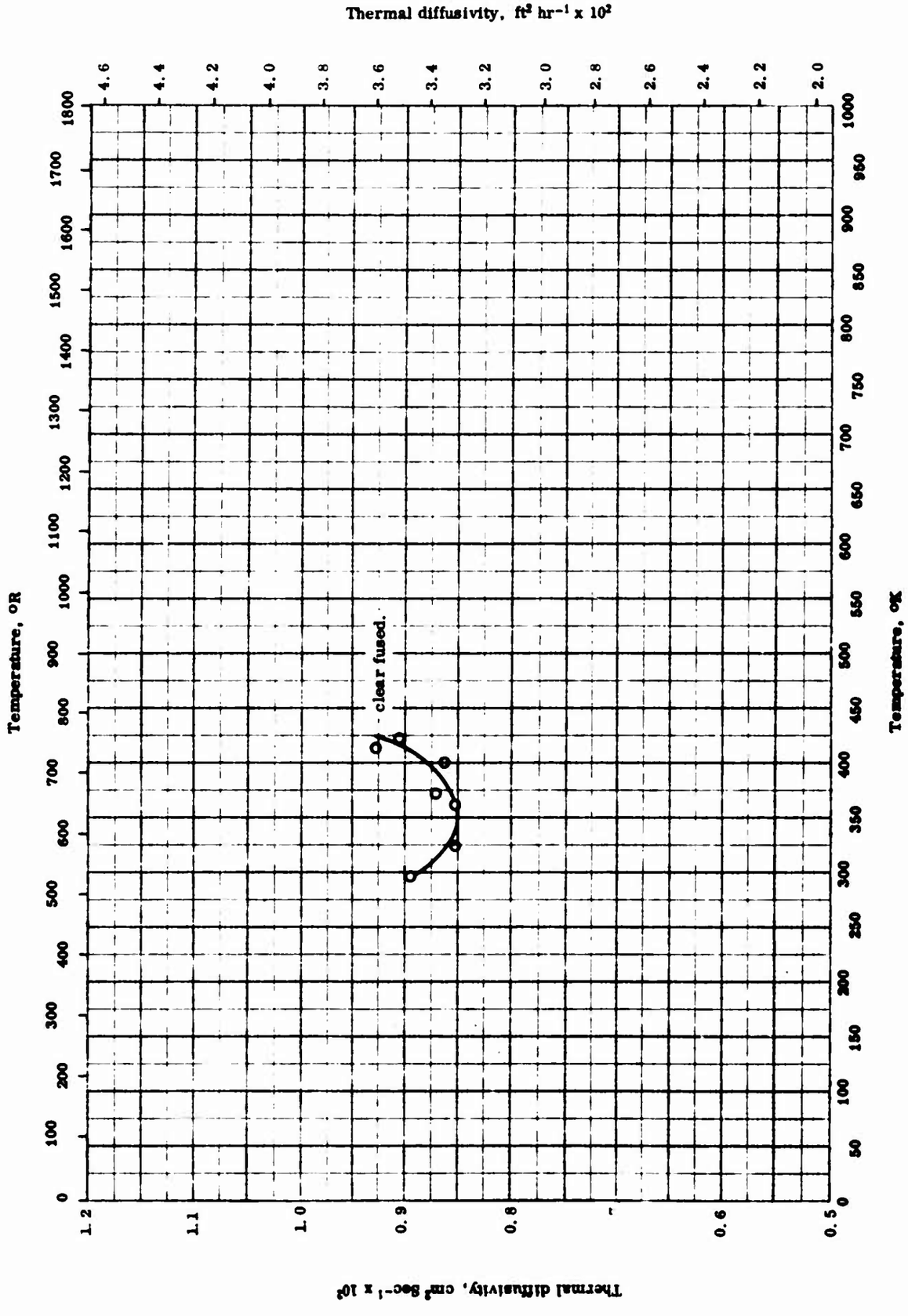


THERMAL DIFFUSIVITY -- SILICON DIOXIDE

THERMAL DIFFUSIVITY -- SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	21-1	773-1373		Silica brick; 95.4 SiO_2; 1.68 CaO, and 0.90 Al_2O_3; texture very open; many large and sub-angular rock fragments; bonding of coarse and fine fairly good, although adherence of some of the grains is only fair; sample dimension 9 by 4 1/2 by 2 1/2 in.; porosity 24.0% and 2.30 true specific gravity.	Heat flow in length-wise direction.
□	61-1	367-589		Not given.	

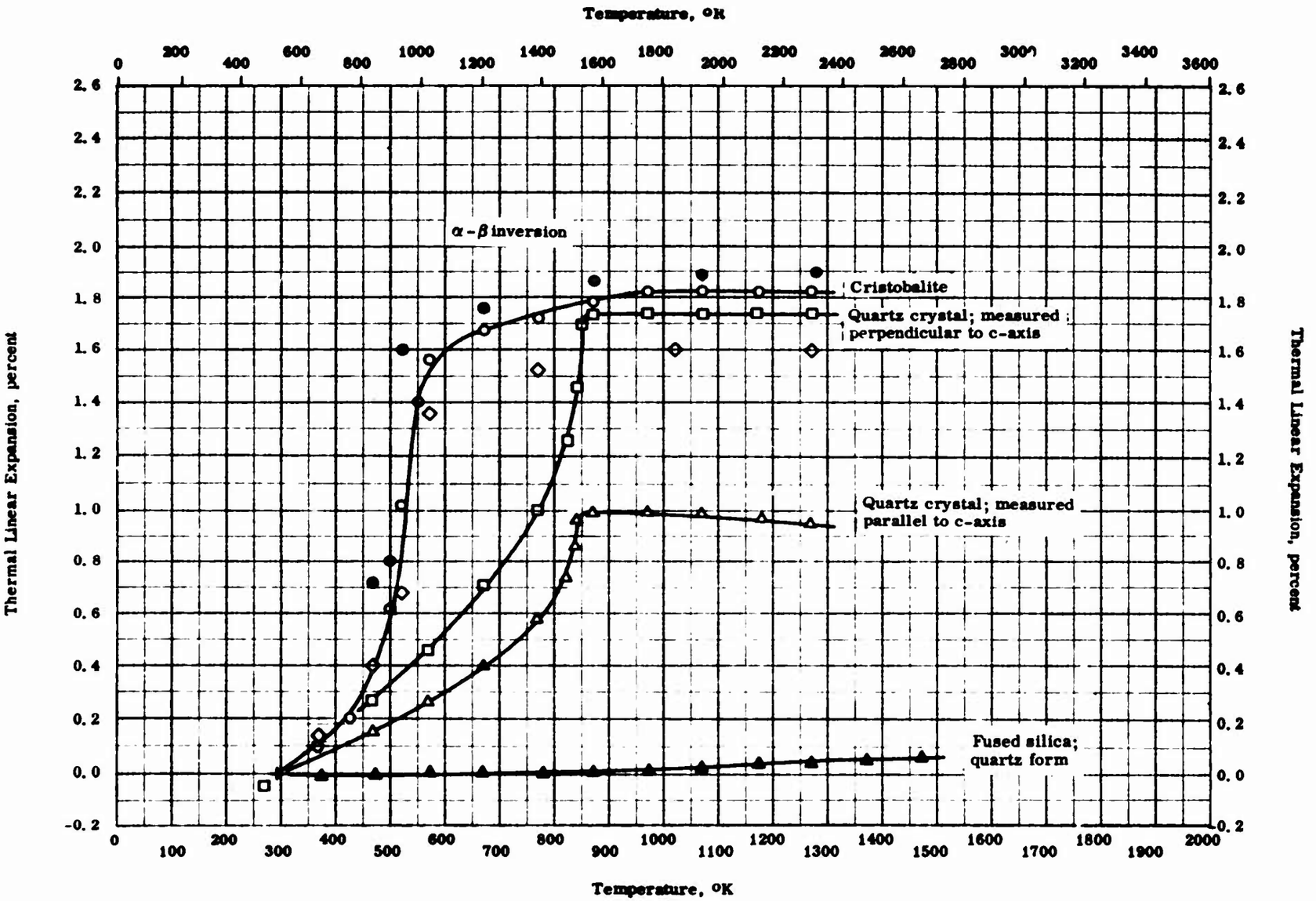


THERMAL DIFFUSIVITY -- SILICON DIOXIDE
(Quartz)

THERMAL DIFFUSIVITY -- SILICON DIOXIDE
(Quartz)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	62-3	297-422		Clear fused.	

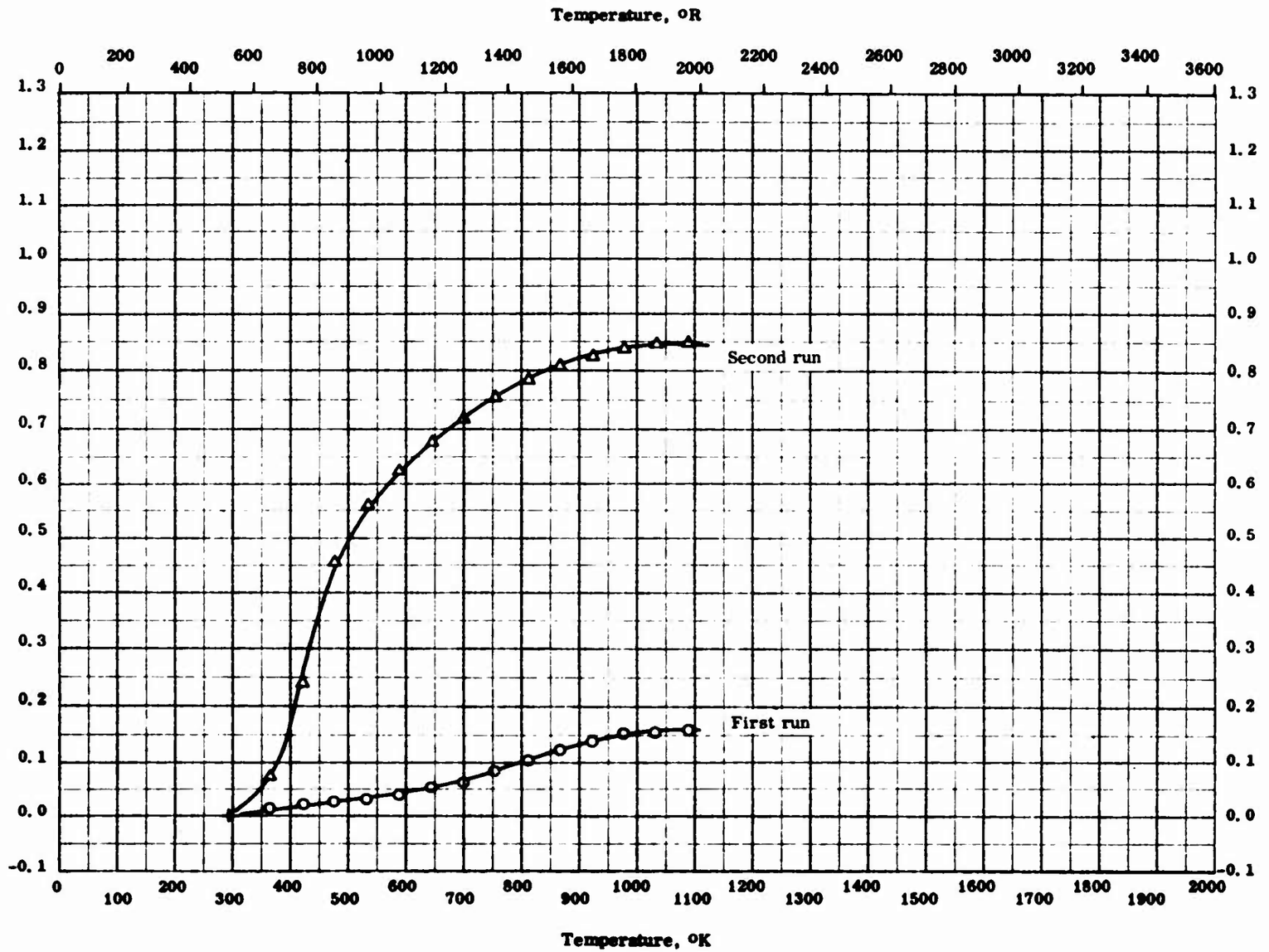


THERMAL LINEAR EXPANSION -- SILICON DIOXIDE

THERMAL LINEAR EXPANSION -- SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▲	61-42	303-1423		SiO_2; fused silica, quartz form.	
○	49-8	298-1273		SiO_2, cristobalite.	Prepared from silica gel, calcined 1 hr at 1500 C, refired with 6% metaphosphate bond, and pressed into bars.
□	46-5	273-1273		Quartz, clear rock crystal from Minas Geraes, Brazil; density 2.649 g cm^{-3}.	Measured perpendicular to c-axis.
△	46-5	273-1273		Same as above.	Measured parallel to c-axis.
◇	51-25	293-1273		SiO_2.	Heated 2 hrs at 1540 C and 8 hrs at 1500 C.
●	51-25	293-1273		99 SiO_2 and 1 TiO_2.	Same as above.



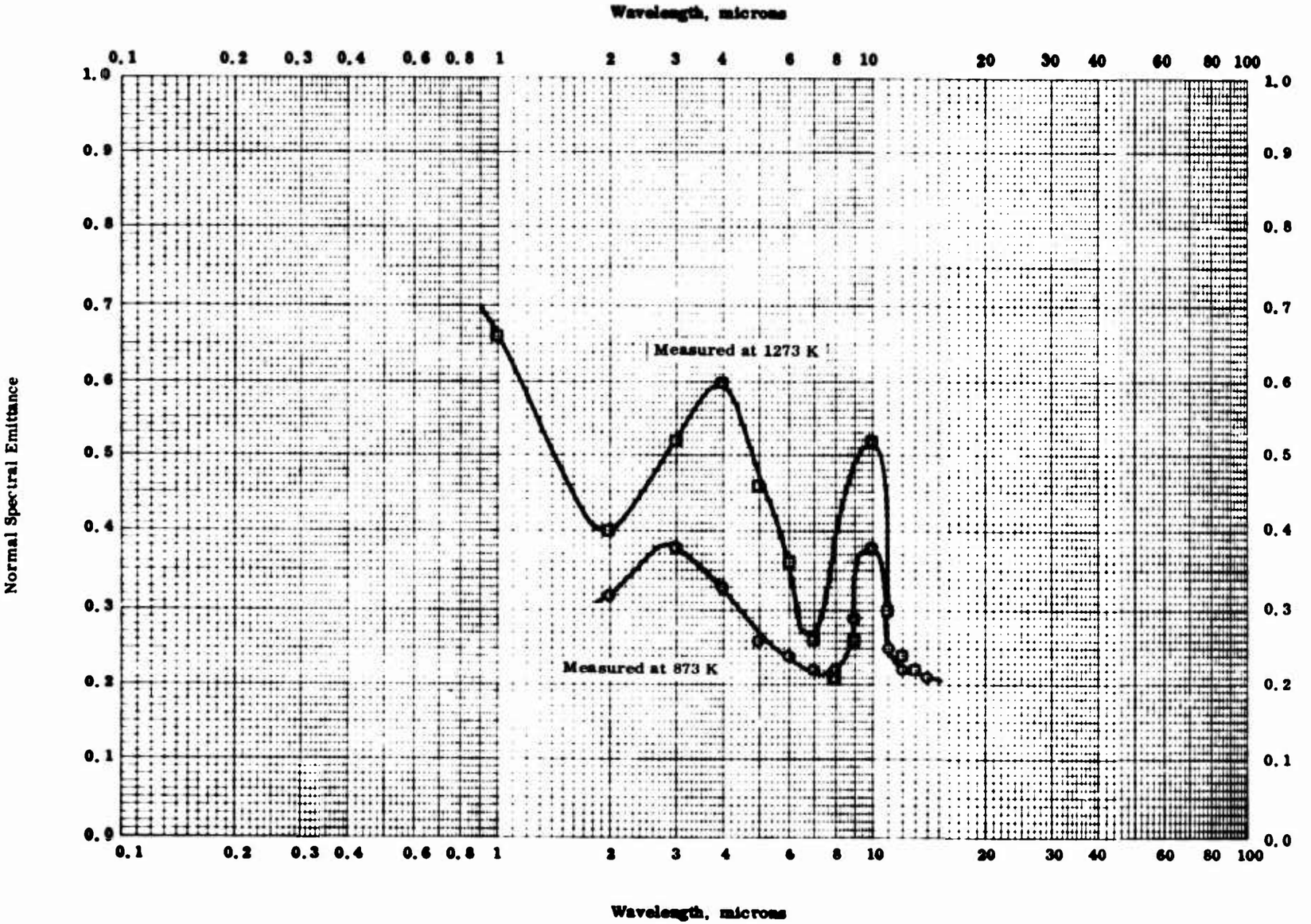
THERMAL LINEAR EXPANSION -- SILICON DIOXIDE FOAM

THERMAL LINEAR EXPANSION -- SILICON DIOXIDE FOAM

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
o	62-30	293-1089		Prepared from 50-55 Glasrock Slip, 30-35 Ludox (colloidal SiO_2), 5-7 -400 mesh SiO_2, 3-6 Al powder, 3-6 carbon powder, and 2-3 microballons; density 40 lb ft^{-3}; dimensions 2 in. long by 1/4 in. square.	Cured at 200 F; temperature raised to 600 F over 24 hrs period and held at 600 F for 8 hrs; reference temperature not given, assumed to be 68 F.
△	62-30	293-1089		Same as above.	Second run for above sample.

TPRC

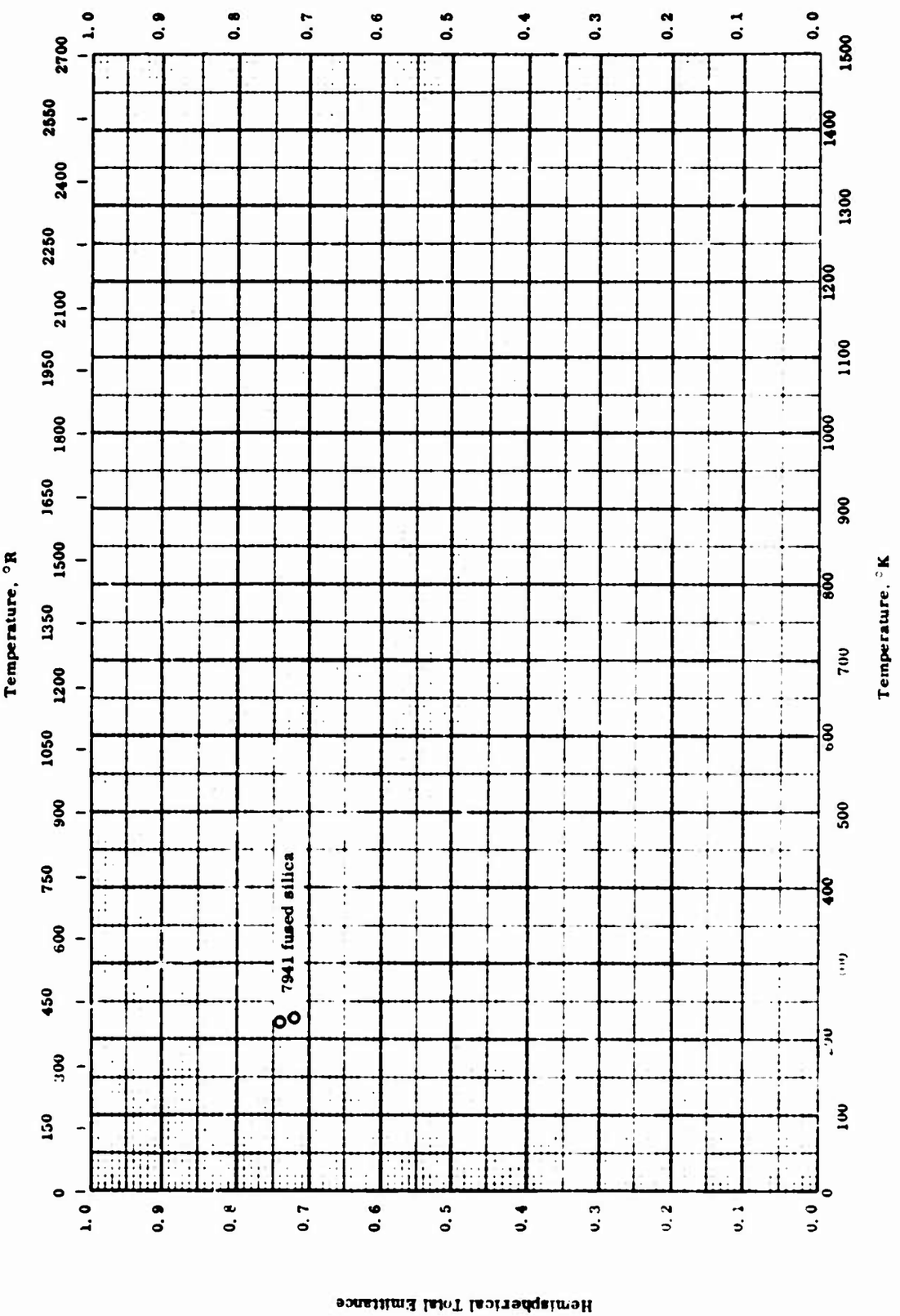


NORMAL SPECTRAL EMITTANCE -- SILICON MONOXIDE

NORMAL SPECTRAL EMITTANCE -- SILICON MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
○	60-30	873	2-14	4	SiO, film 0.1μ thickness.	Vacuum deposited on polished platinum bar.
□	60-30	1273	1-14	4	SiO, film 0.1μ thickness on polished Inconel.	Some oxidation occurred at coating - substrate interface.

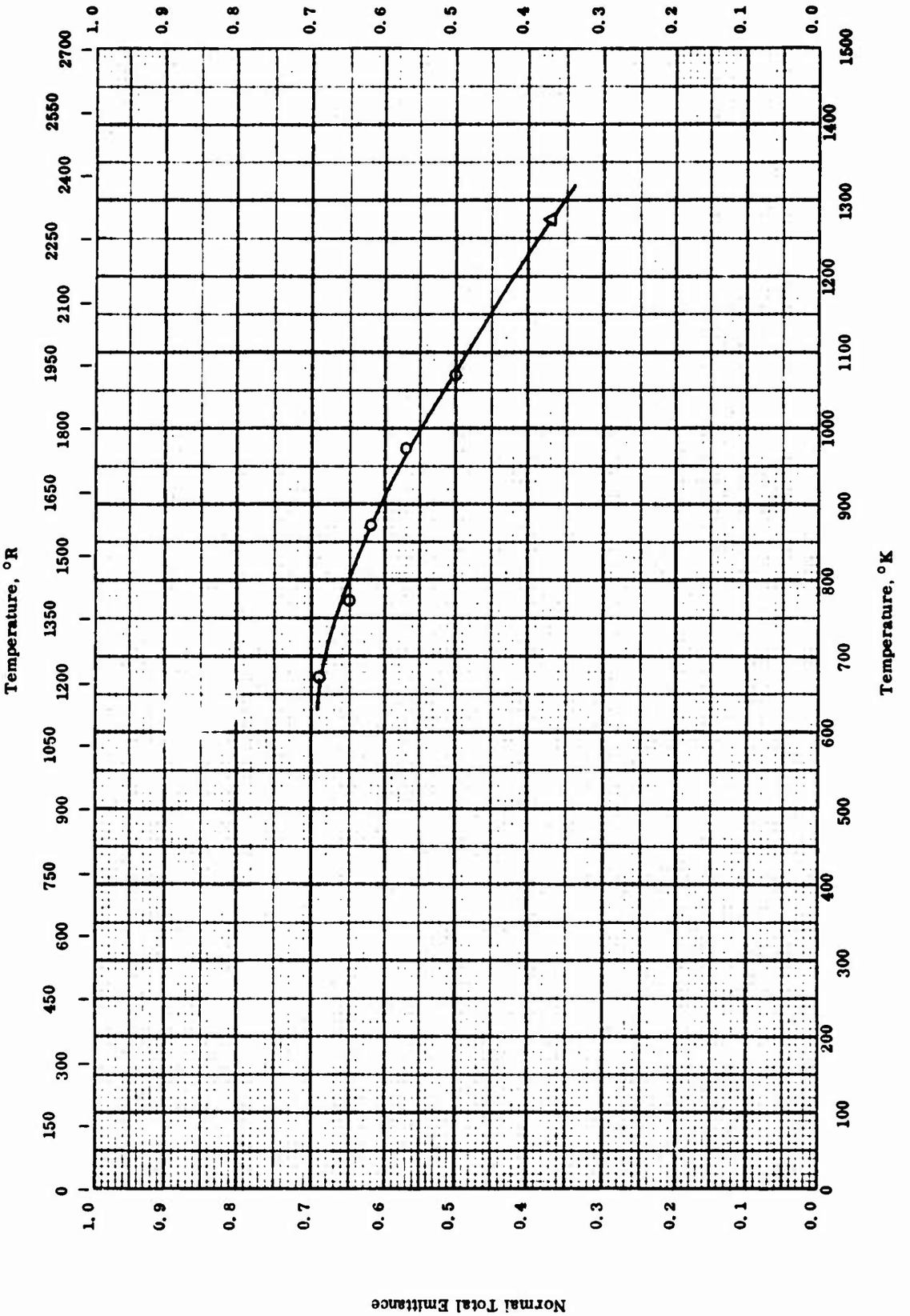


HEMISPHERICAL TOTAL EMITTANCE -- SILICON DIOXIDE

HEMISPHERICAL TOTAL EMITTANCE -- SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-27	221-229	± 2.5	SiO_2; 7941 fused silica.	Measured in vacuum (0.2×10^{-4} mm Hg).

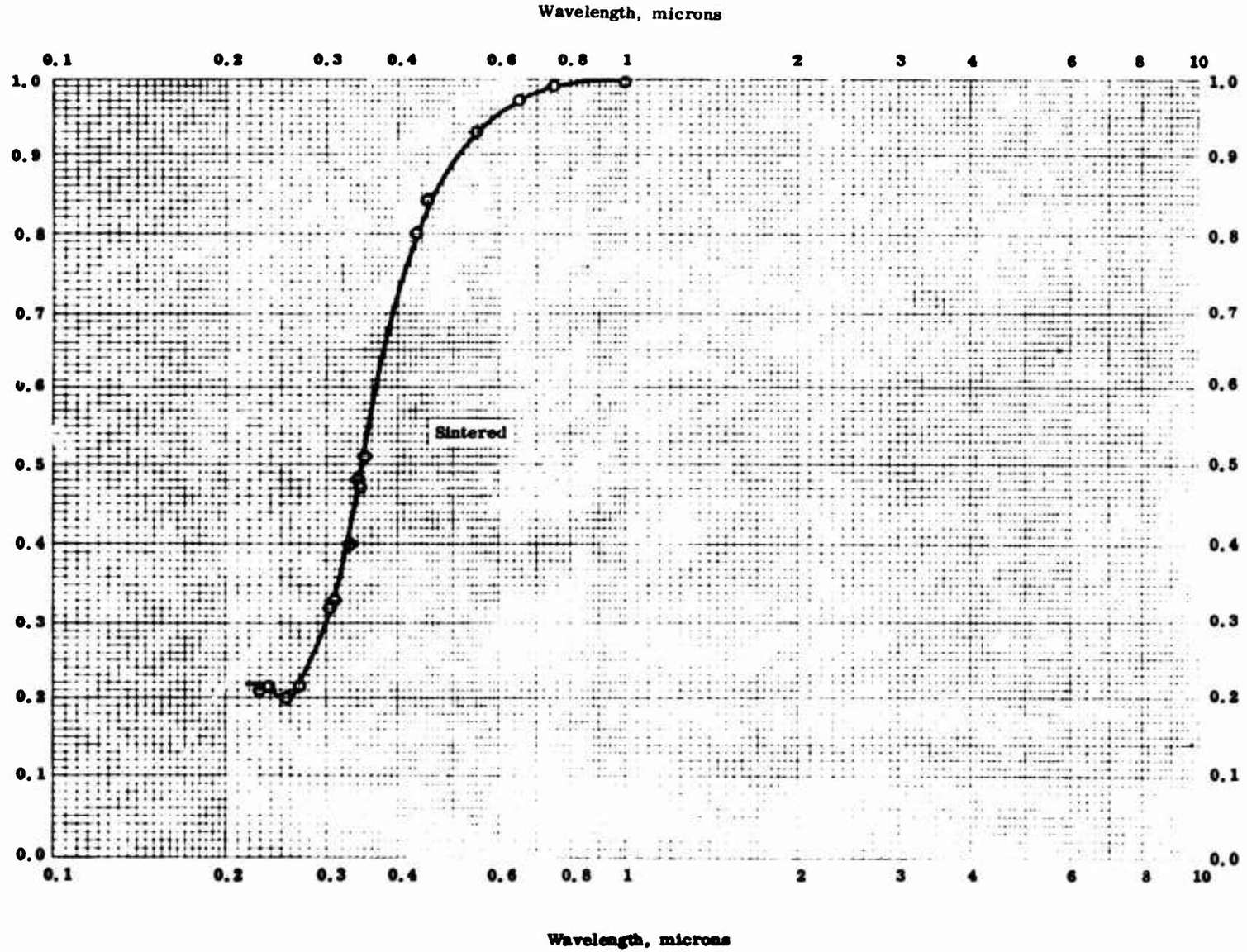


NORMAL TOTAL EMITTANCE -- SILICON DIOXIDE

NORMAL TOTAL EMITTANCE -- SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	52-17	673-1073		SiO_2; powder coating on Nimonic 75 strip.	Crushed silica milled into powder, treated with 50% HCl; heated in air.
Δ	62-23	1273		SiO_2, 99.6 pure; 0.11 in. thickness plate.	Sintered at 1823 K for 1 hr; computed from spectral data.



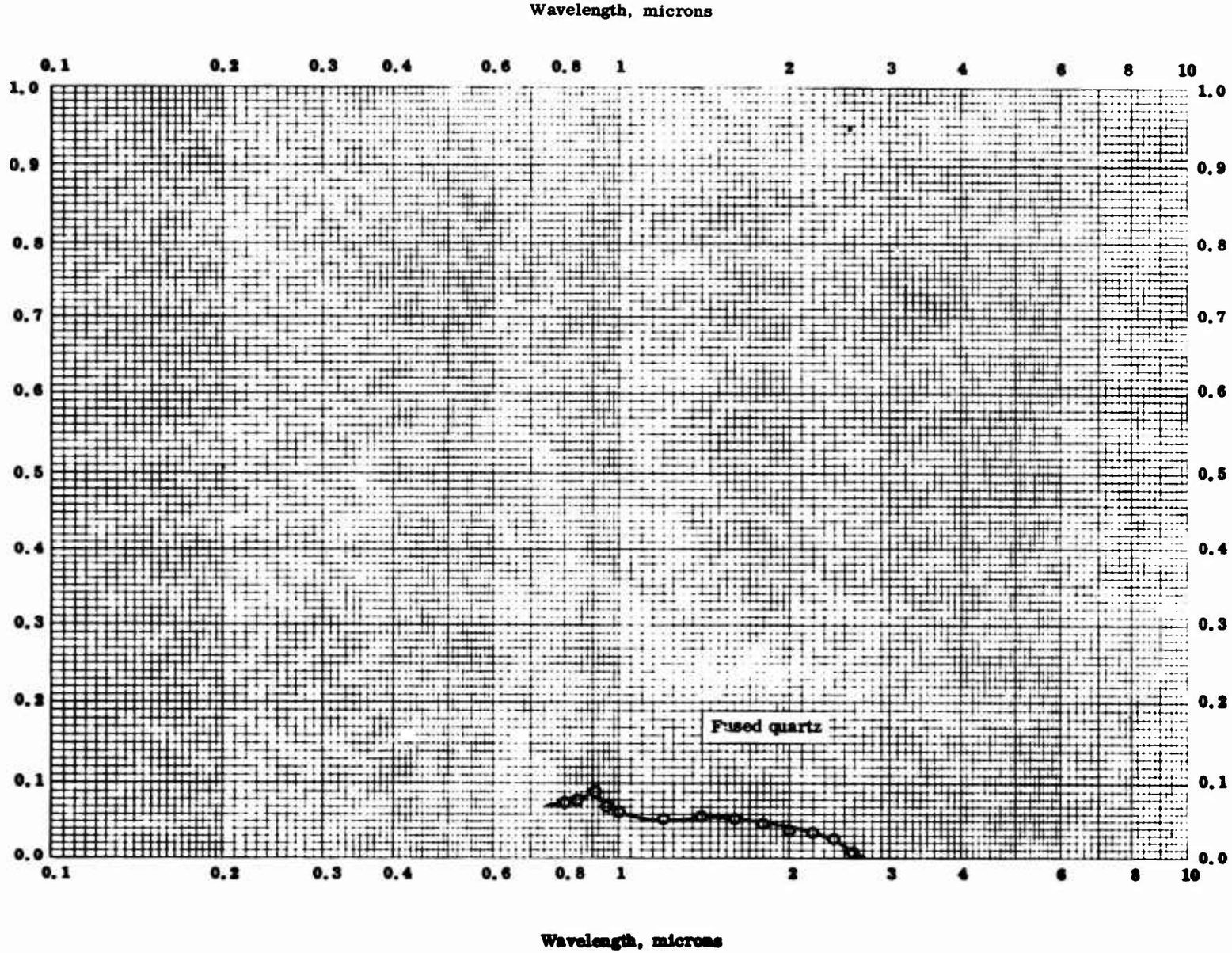
NORMAL SPECTRAL REFLECTANCE -- SILICON DIOXIDE

NORMAL SPECTRAL REFLECTANCE -- SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Rang, μ	Rept. Error %	Sample Specifications	Remarks
O	63-26	298	0.23 - 1.00		SiO_2, pure; 0.15 in. thickness plate; density 1.46 g cm^{-3}.	Sintered at 1823 K for 2 hrs; data taken from a curve; normal incidence, hemispherical viewing; MgO as reference standard.

TPRC

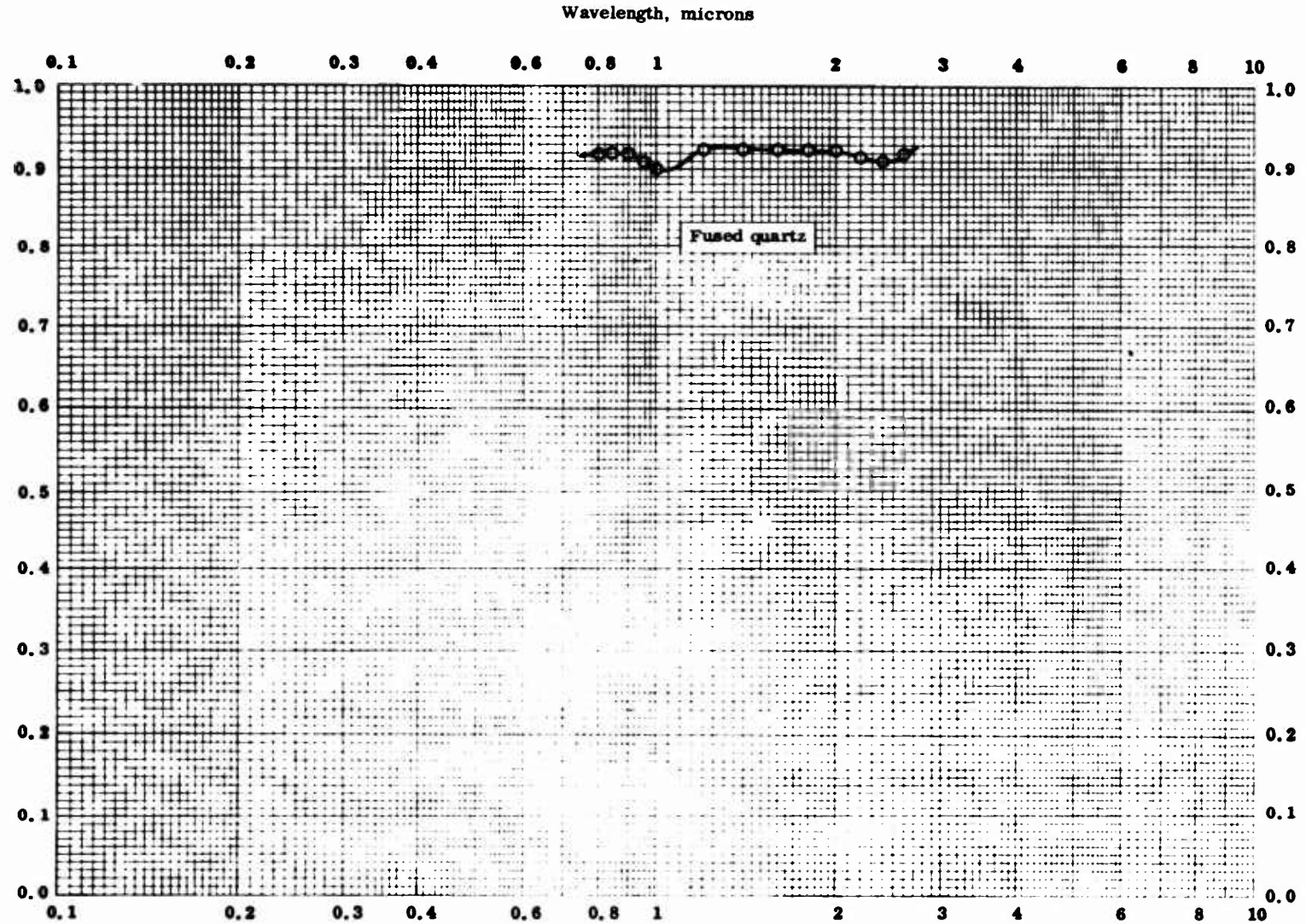


ANGULAR SPECTRAL REFLECTANCE -- SILICON DIOXIDE

ANGULAR SPECTRAL REFLECTANCE -- SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	64-10	298	0.8 - 2.6		SiO_2, clear fused quartz.	45° illumination, 45° viewing; aluminum as reference standard; measured in air.

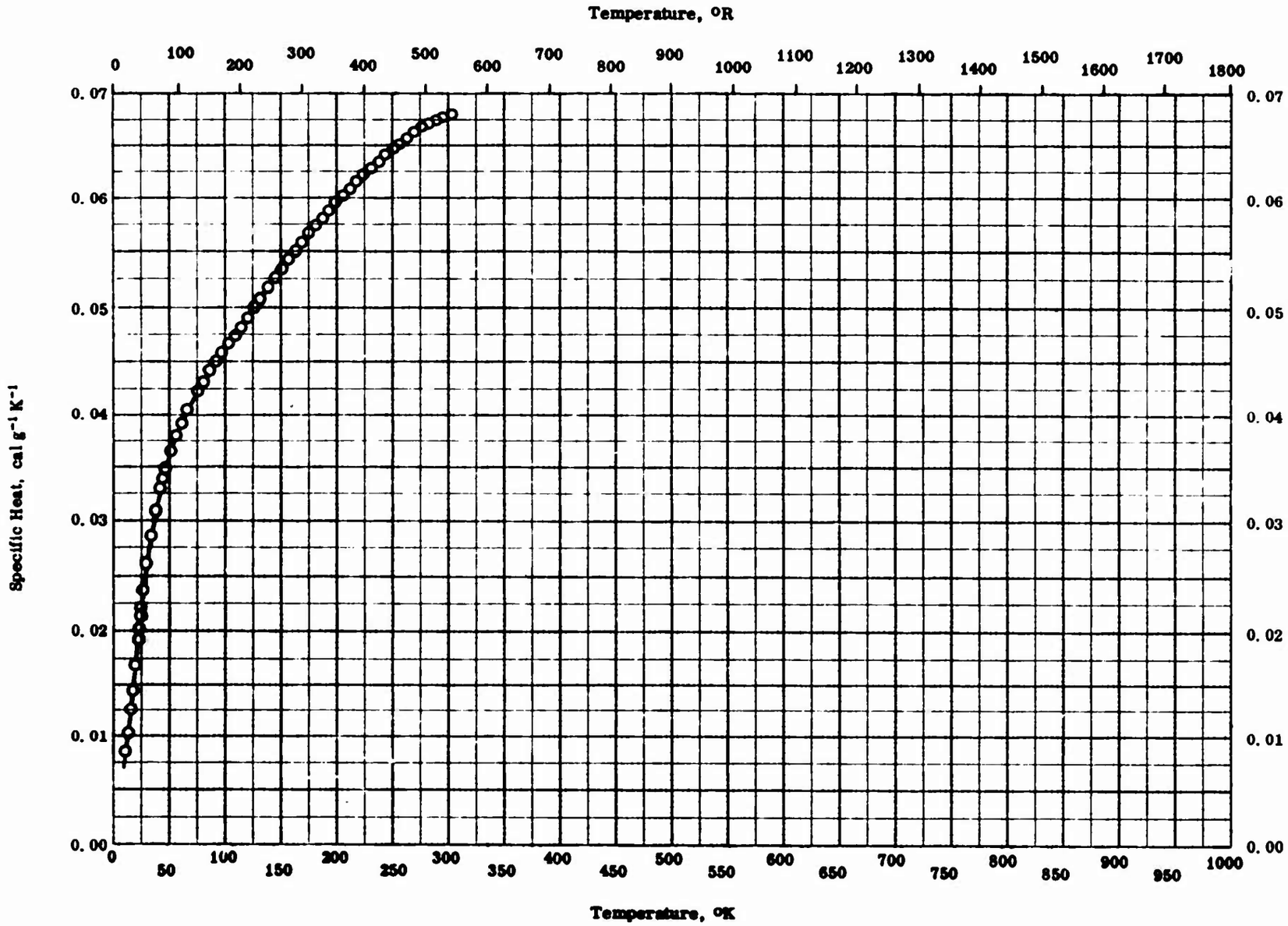


NORMAL SPECTRAL TRANSMITTANCE -- SILICON DIOXIDE

NORMAL SPECTRAL TRANSMITTANCE -- SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
O	64-10	298	0.8-2.6		SiO_2, clear, fused quartz.	Measured in air.

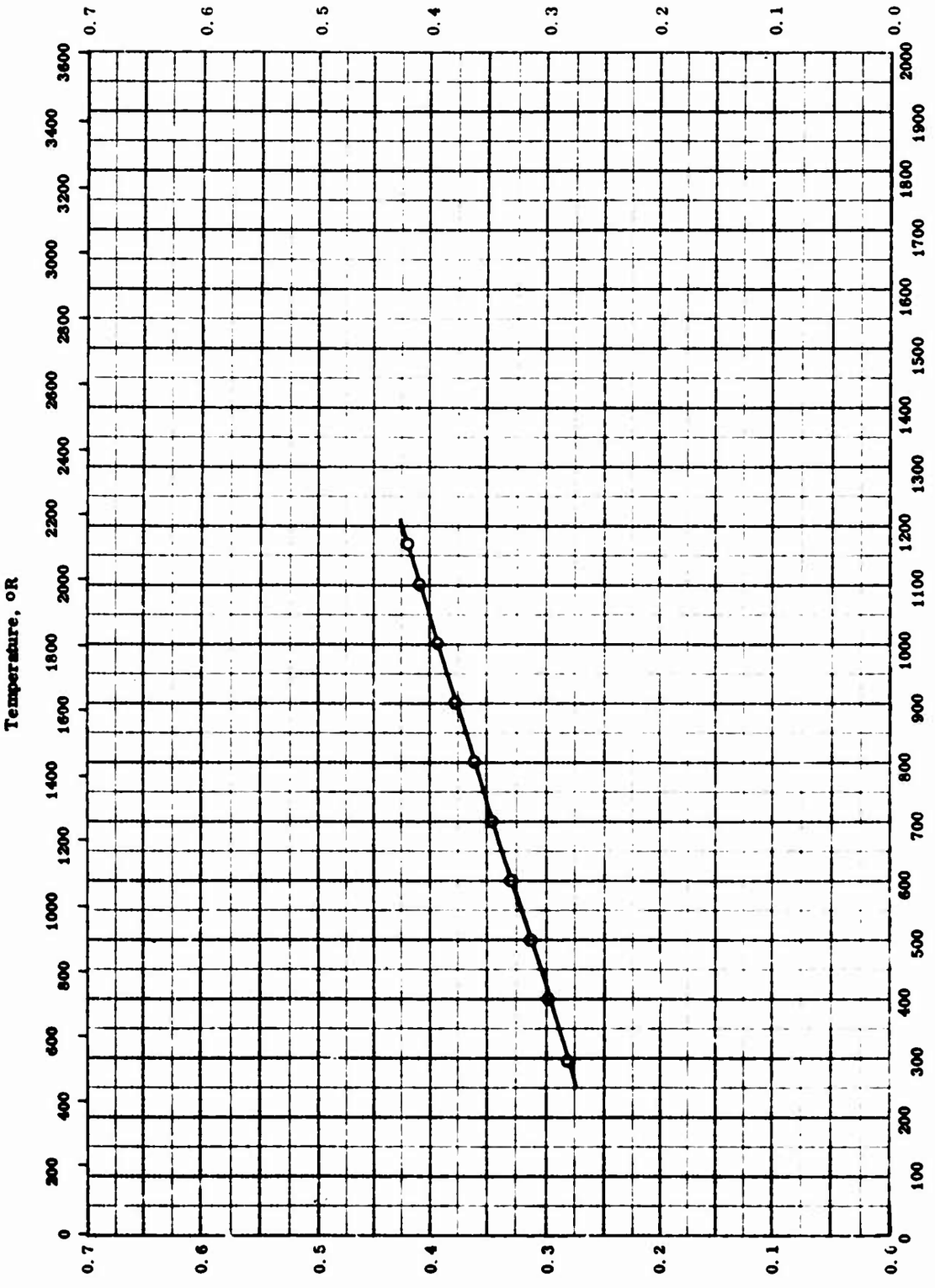


SPECIFIC HEAT -- SILVER OXIDE

SPECIFIC HEAT -- SILVER OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	62-7	14-301		99.9 Ag_2O, 0.05 Cu, 0.04 H_2O, 0.01 other impurities.	Annealed under helium atm.



SPECIFIC HEAT -- SODIUM MONOXIDE

SPECIFIC HEAT -- SODIUM MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	60-8	298-1170	±2.0	96.76 Na_2O, 1.33 Na_2CO_3, and 0.91 Na_2O_2.	

TPRC

PROPERTIES OF STRONTIUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density	4.7*	294*
Melting Point	2703	4865
Heat of Sublimation	1216_{0K}	2189_{0R}

* Handbook of Chemistry and Physics (Ref. 64-16)

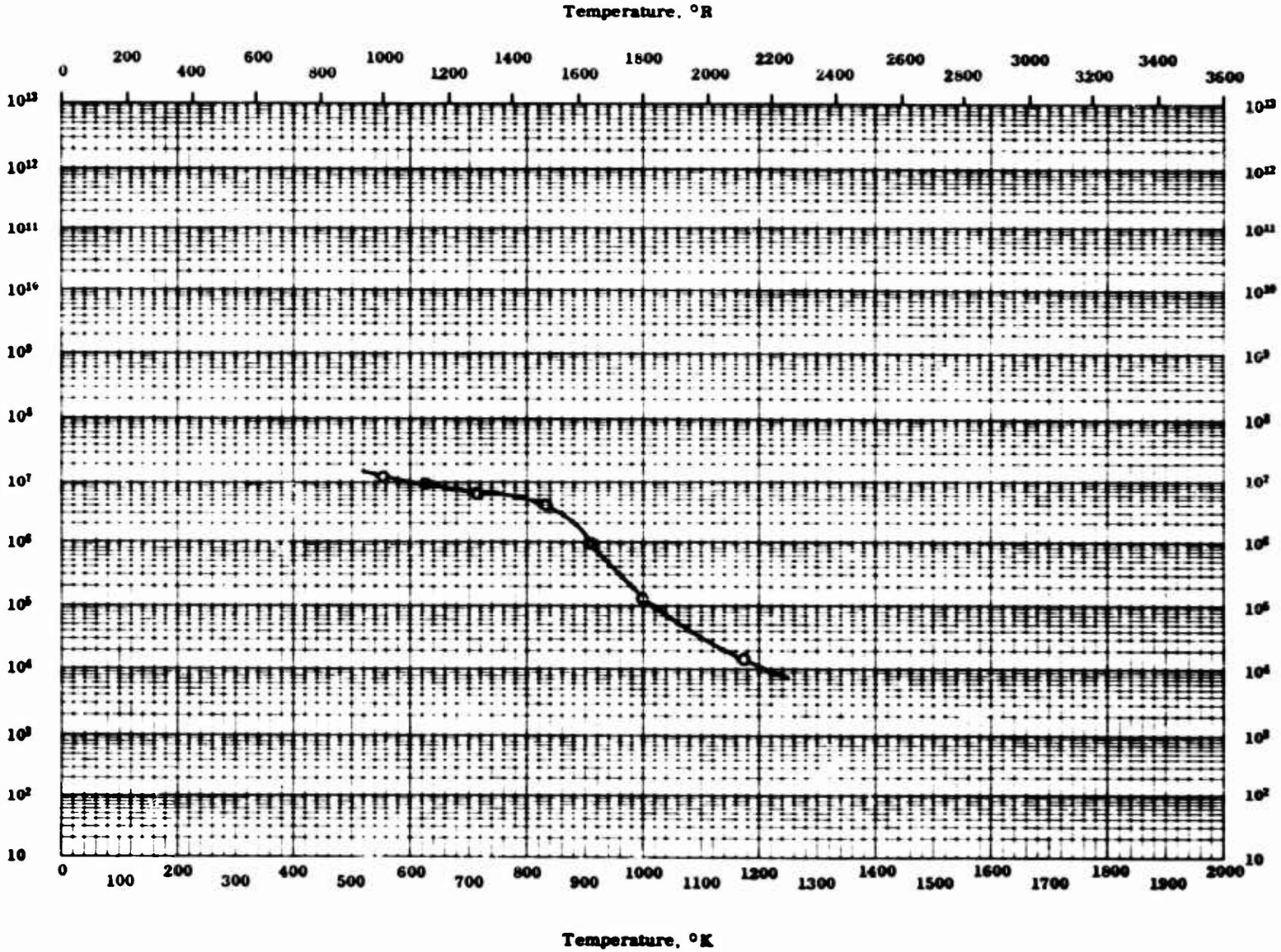
REPORTED VALUES

Melting Point	K	R
	○ 2703	4865
Heat of Sublimation	**cal g^{-1}**	**Btu lb^{-1}**
	□ $1216_{0K} \pm 8$	$2189_{0R} \pm 14$

PROPERTIES OF STRONTIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	49-3	2703		SrO.	
□	50-4	0		SrO.	Δh_s from vapor pressure data.



TPRC

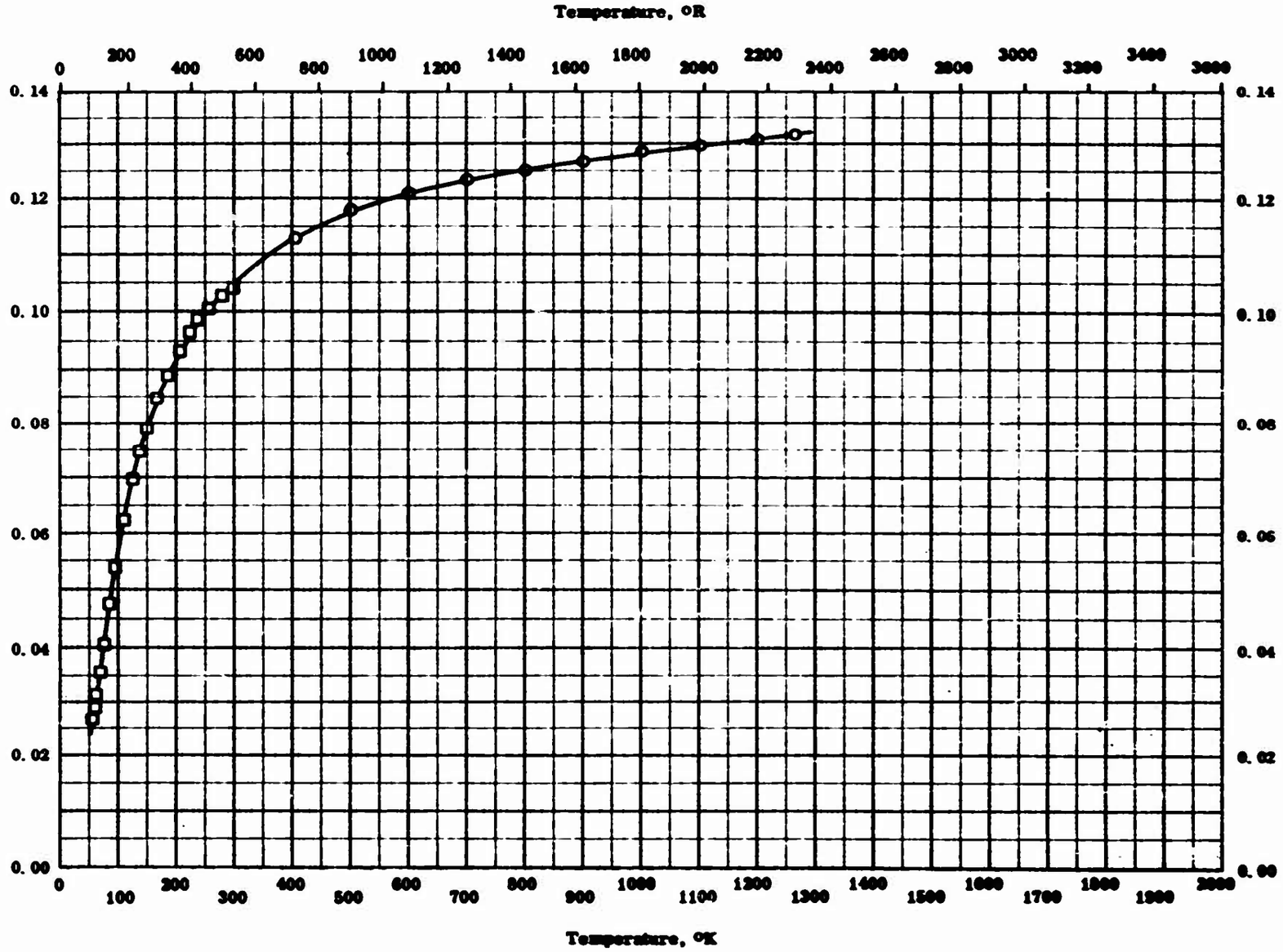
ELECTRICAL RESISTIVITY -- STRONTIUM OXIDE

ELECTRICAL RESISTIVITY -- STRONTIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	56-13	556-1178		SrO; polycrystal; formed from chemically pure materials.	Baked polycrystalline samples, calcined 2 hrs at const. temp. in furnace; meas. under 10^{-5} mm Hg vacuum, const. current.

TPRC

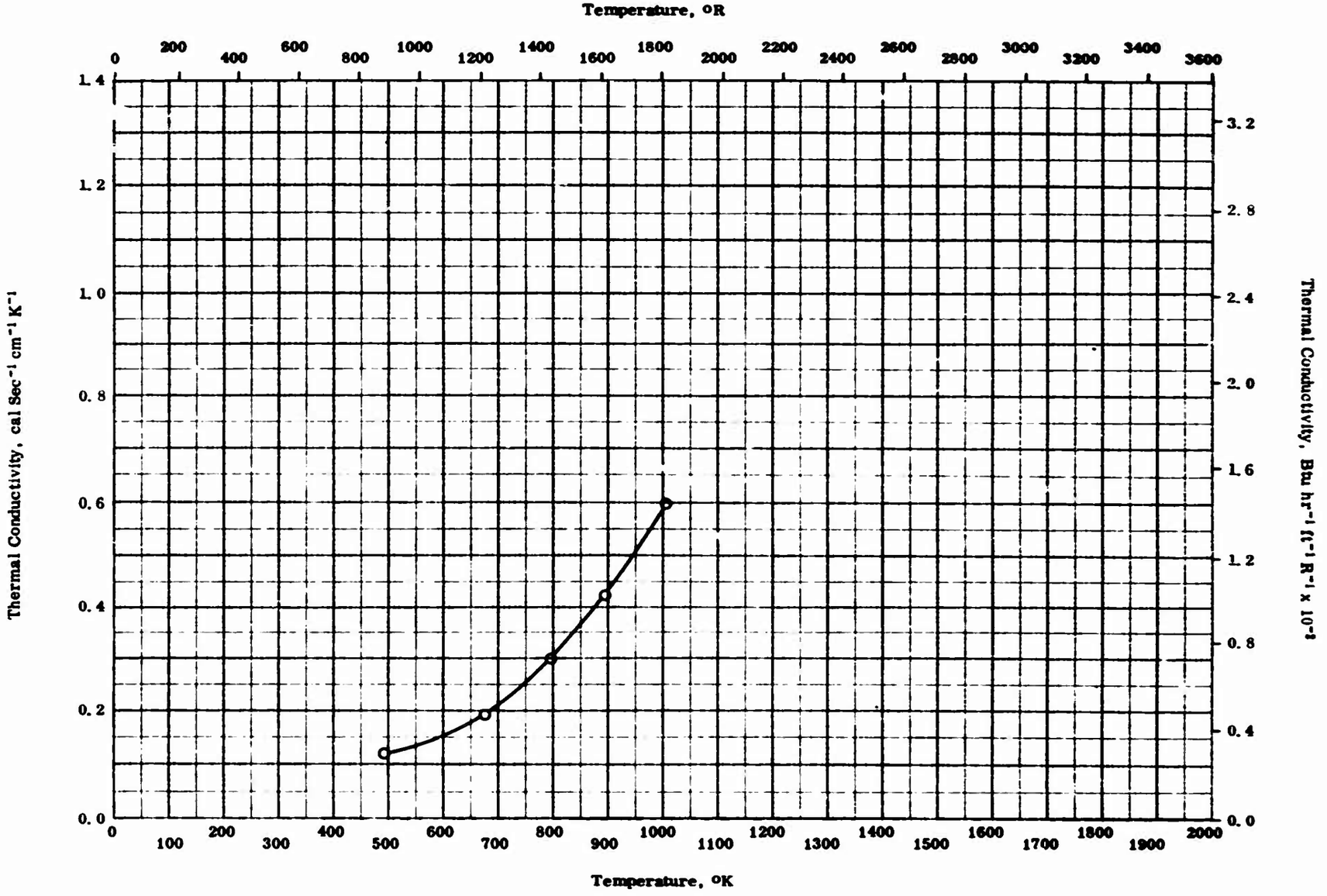


SPECIFIC HEAT -- STRONTIUM OXIDE

SPECIFIC HEAT -- STRONTIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	51-10	405-1265		SrO.	Obtained by thermal decomposition of $SrCO_2$ at 1000 C in a vacuum.
□	35-1	58-298		Kahlbaum best grade; impurities mainly carbonate; - 14 ± 35 mesh size.	Under helium atm.

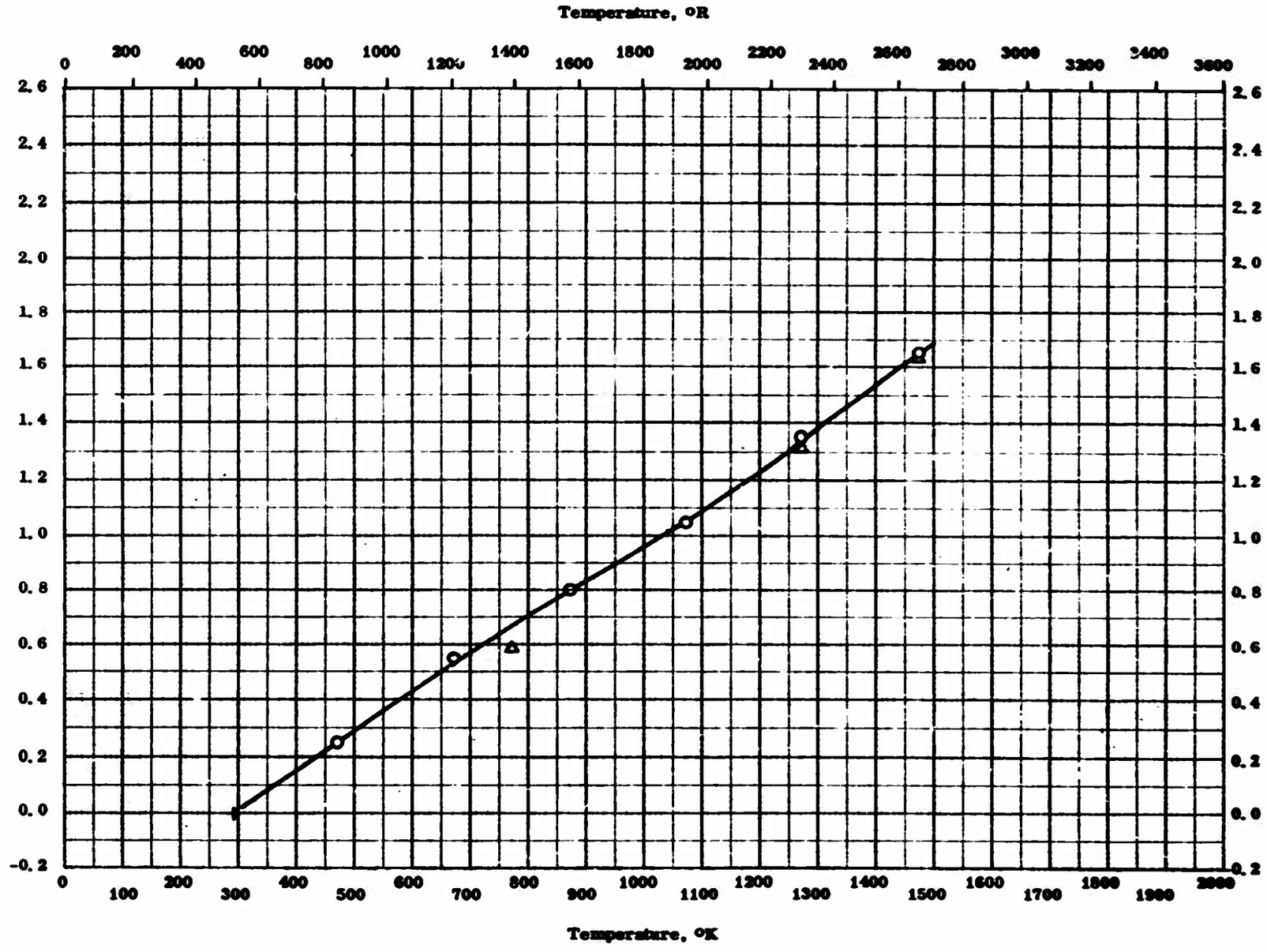


THERMAL CONDUCTIVITY -- STRONTIUM OXIDE

THERMAL CONDUCTIVITY -- STRONTIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	55-8	493-1000		Polycrystal.	

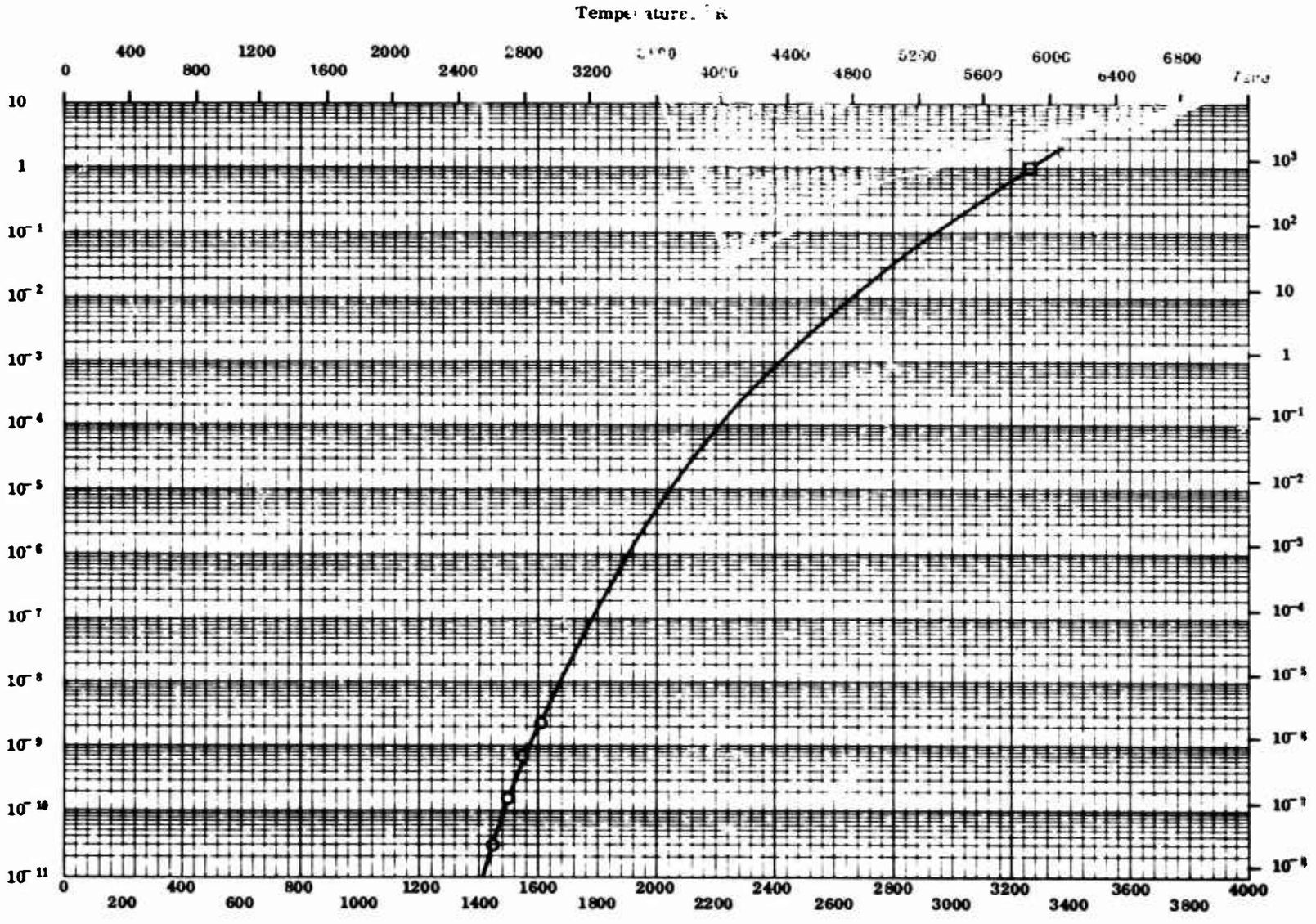


THERMAL LINEAR EXPANSION -- STRONTIUM OXIDE

THERMAL LINEAR EXPANSION -- STRONTIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Repr. Error %	Sample Specifications	Remarks
Δ	60-35	298-1473		SrO.	
O	57-34	293-1473		Reagent grade SrO.	Measured by x-ray back reflection.



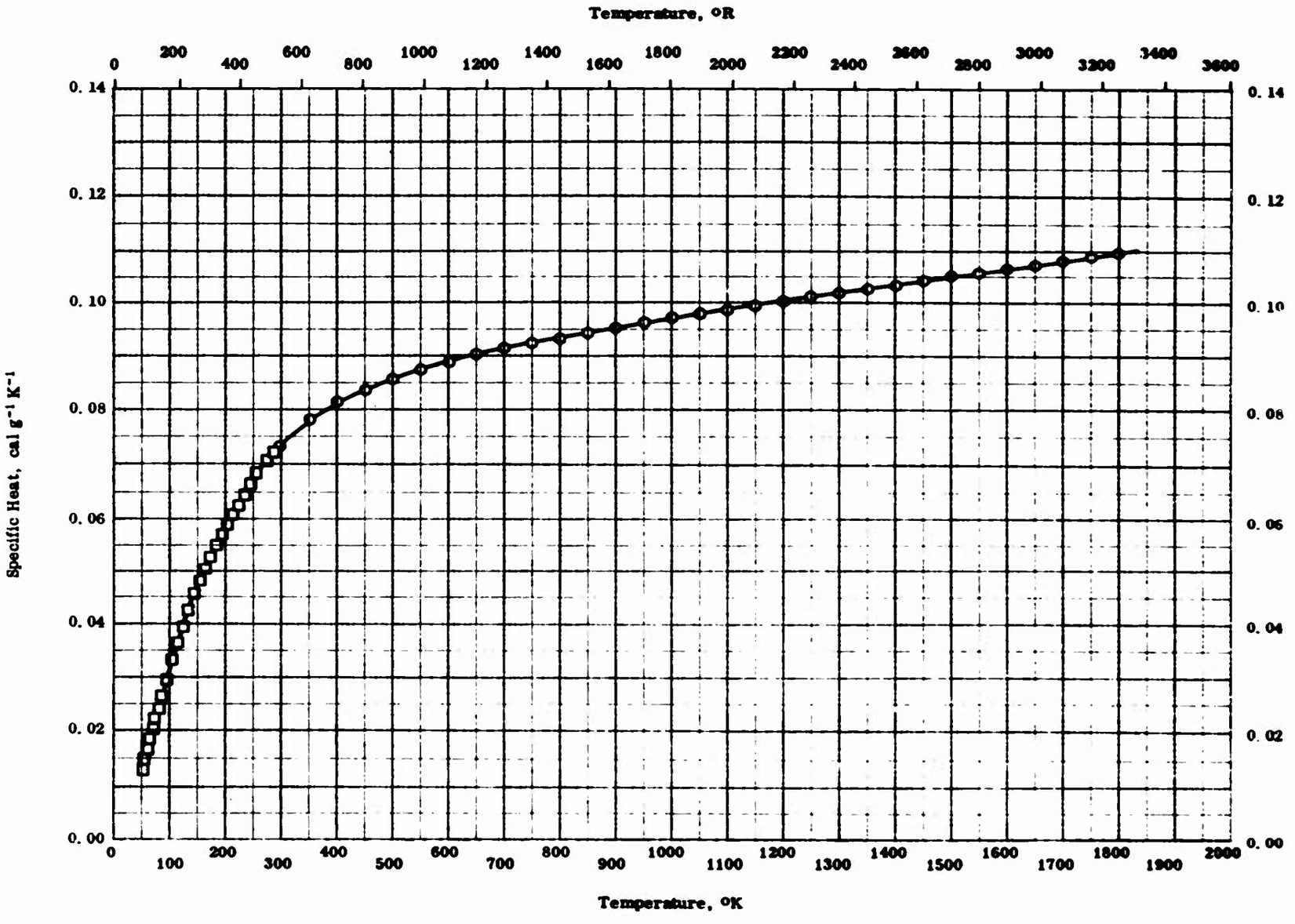
TPRC

VAPOR PRESSURE - STRONTIUM OXIDE

VAPOR PRESSURE -- STRONTIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	50-4	700-1600		Not given.	Pt filament with SrO coating.
□	49-3	3272	± 1	Not given.	



SPECIFIC HEAT -- TANTALUM PENTOXIDE

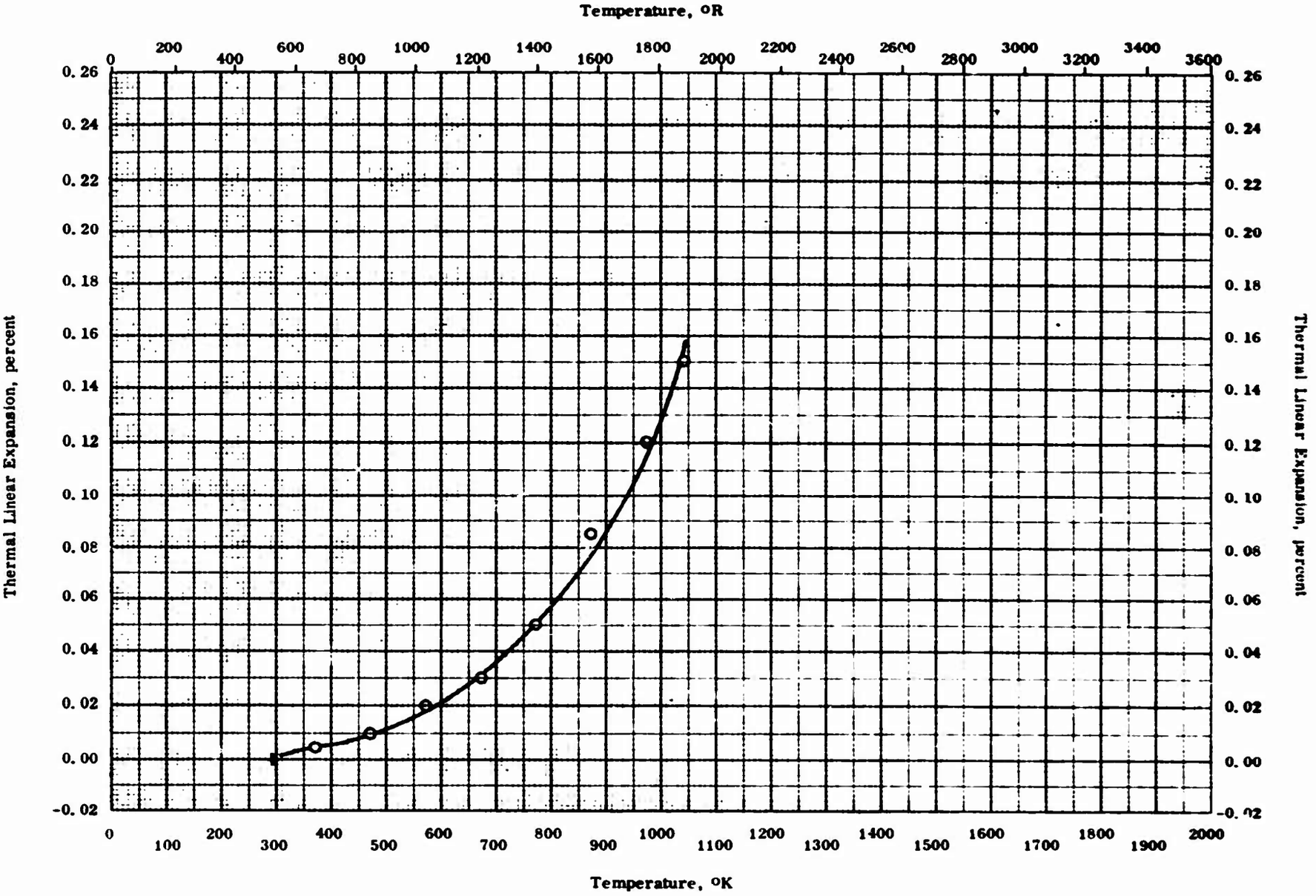
TPRC

SPECIFIC HEAT -- TANTALUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	53-11	298-1800		Virtually atomic weigh' purity Ta_2O_5.	Heated to 1200 C before testing.
□	40-1	53-294		Same as above.	Compressed into pellets.

TPRC

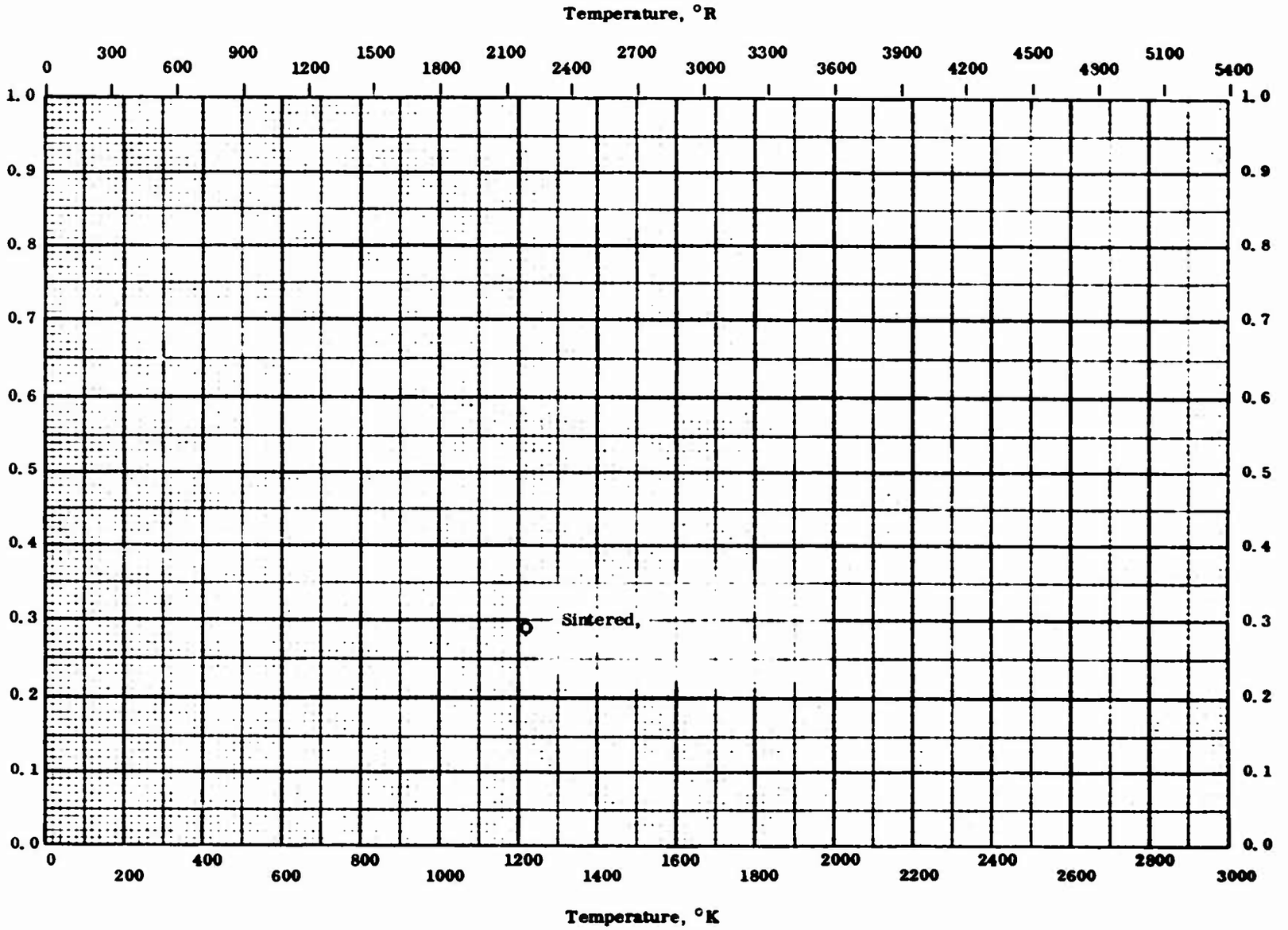


THERMAL LINEAR EXPANSION -- TANTALUM PENTOXIDE

THERMAL LINEAR EXPANSION -- TANTALUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	52-12	293-1043		Ta_2O_5.	Fired to 1425 C and furnace cooled.

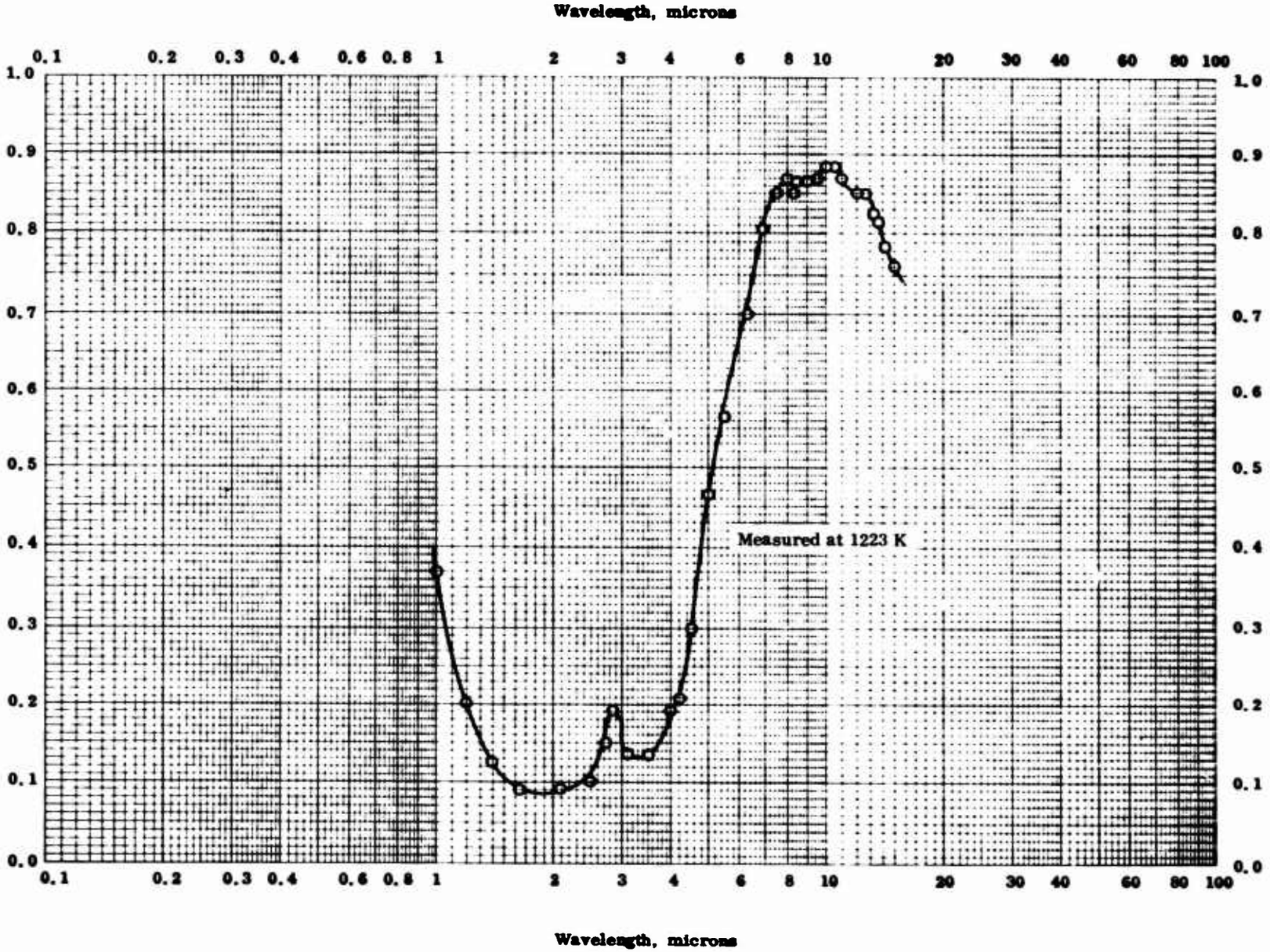


NORMAL TOTAL EMITTANCE -- TANTALUM PENTOXIDE

NORMAL TOTAL EMITTANCE -- TANTALUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-26	1223	±8	Ta_2O_5, 0.047 in. thickness; density 6.51 g cm^{-3}.	Sintered at 1673 K for 2 hrs; measured in argon atmosphere; computed from spectral data.

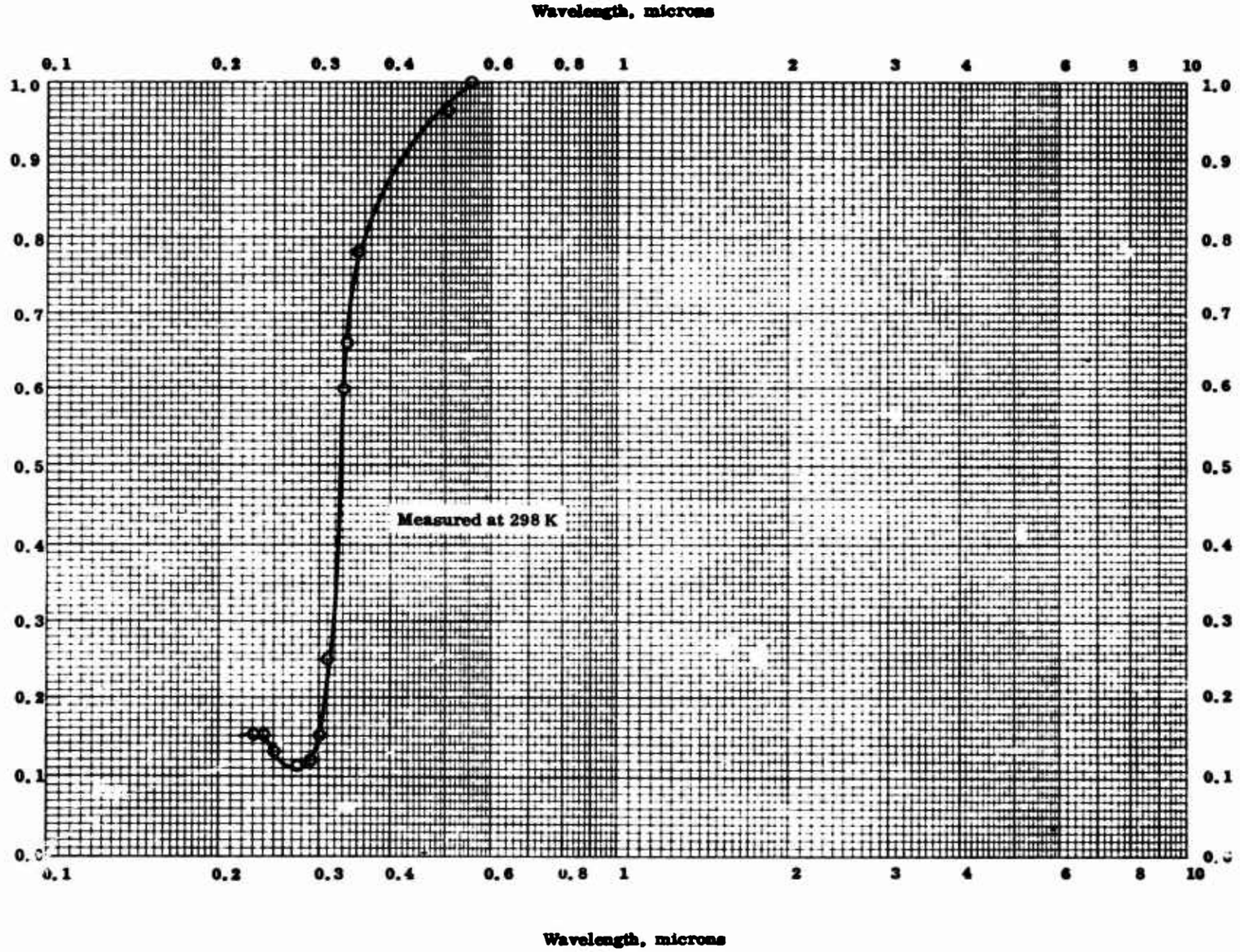


NORMAL SPECTRAL EMITTANCE -- TANTALUM PENTOXIDE

NORMAL SPECTRAL EMITTANCE -- TANTALUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
O	63-26	1223	1-15		Ta_2O_5, 0.047 in. thickness; density 6.51 g cm^{-3}.	Sintered at 1673 K for 2 hrs; measured in argon atmosphere; data taken from a curve.



NORMAL SPECTRAL REFLECTANCE -- TANTALUM PENTOXIDE

Normal Spectral Reflectance

NORMAL SPECTRAL REFLECTANCE -- TANTALUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Repr. Error%	Sample Specifications	Remarks
O	63-26	298	0.23-0.55	5	Ta_2O_5, 0.055 in. thickness; density 4.63 g cm^{-3}.	Sintered at 1573 K for 2 hrs; data taken from a curve; normal illumination, hemispherical viewing; MgO as reference standard.

TPRC

PROPERTIES OF TELLURIUM DIOXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	5.67*	354*
Melting Point	1005.8	1810
Heat of Sublimation	360_{905K}	649_{1629R}

*Handbook of Chemistry and Physics, 45th Ed., 1964

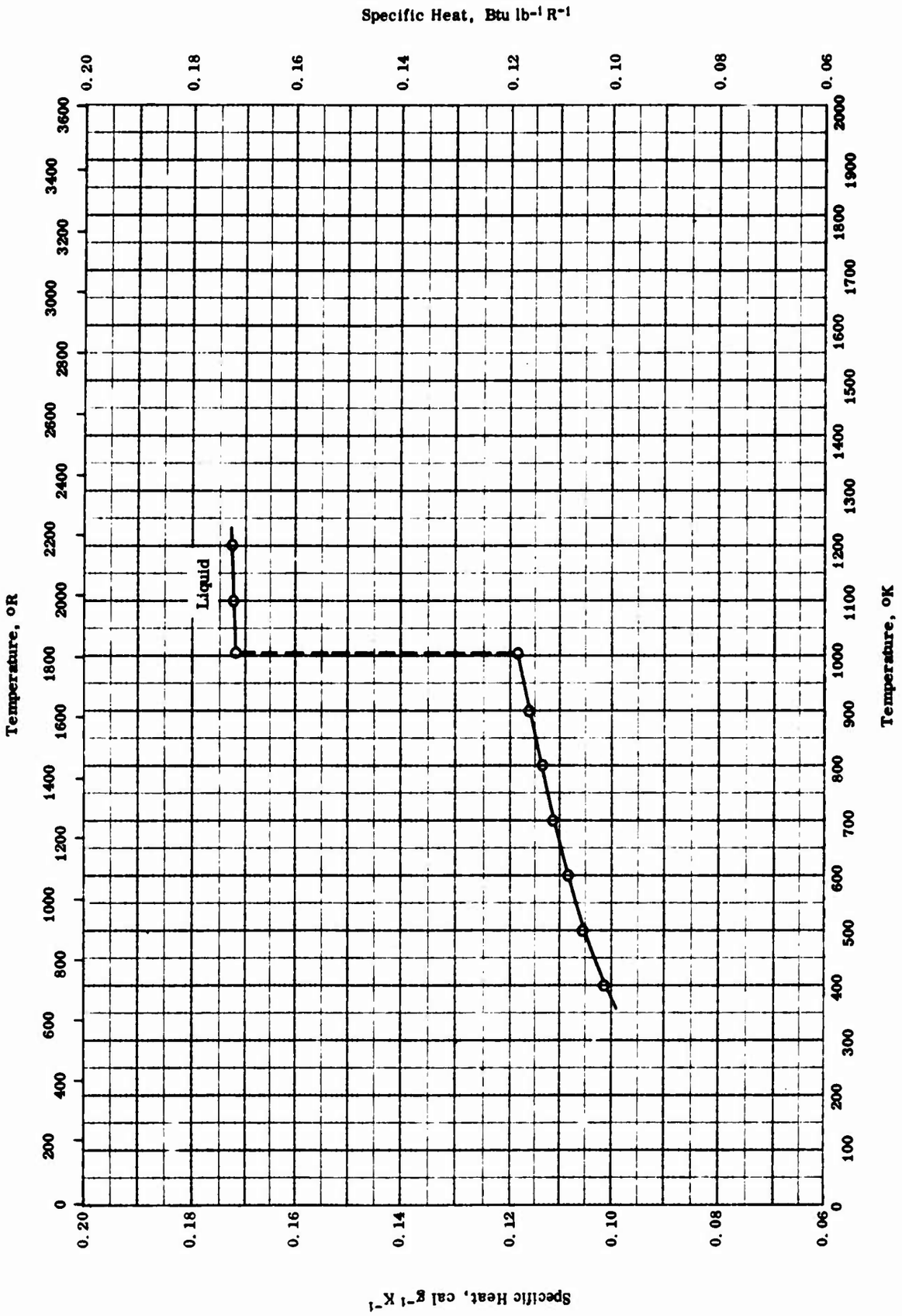
REPORTED VALUES

Melting Point		K	R
	□	1005.8	1810
Heat of Sublimation		cal g^{-1}	Btu lb^{-1}
	○	360_{905K}	649_{1629R}

PROPERTIES OF TELLURIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	41-1	905		TeO_2.	Δh_s from vapor pressure data.
□	42-6	1005.8		TeO_2.	

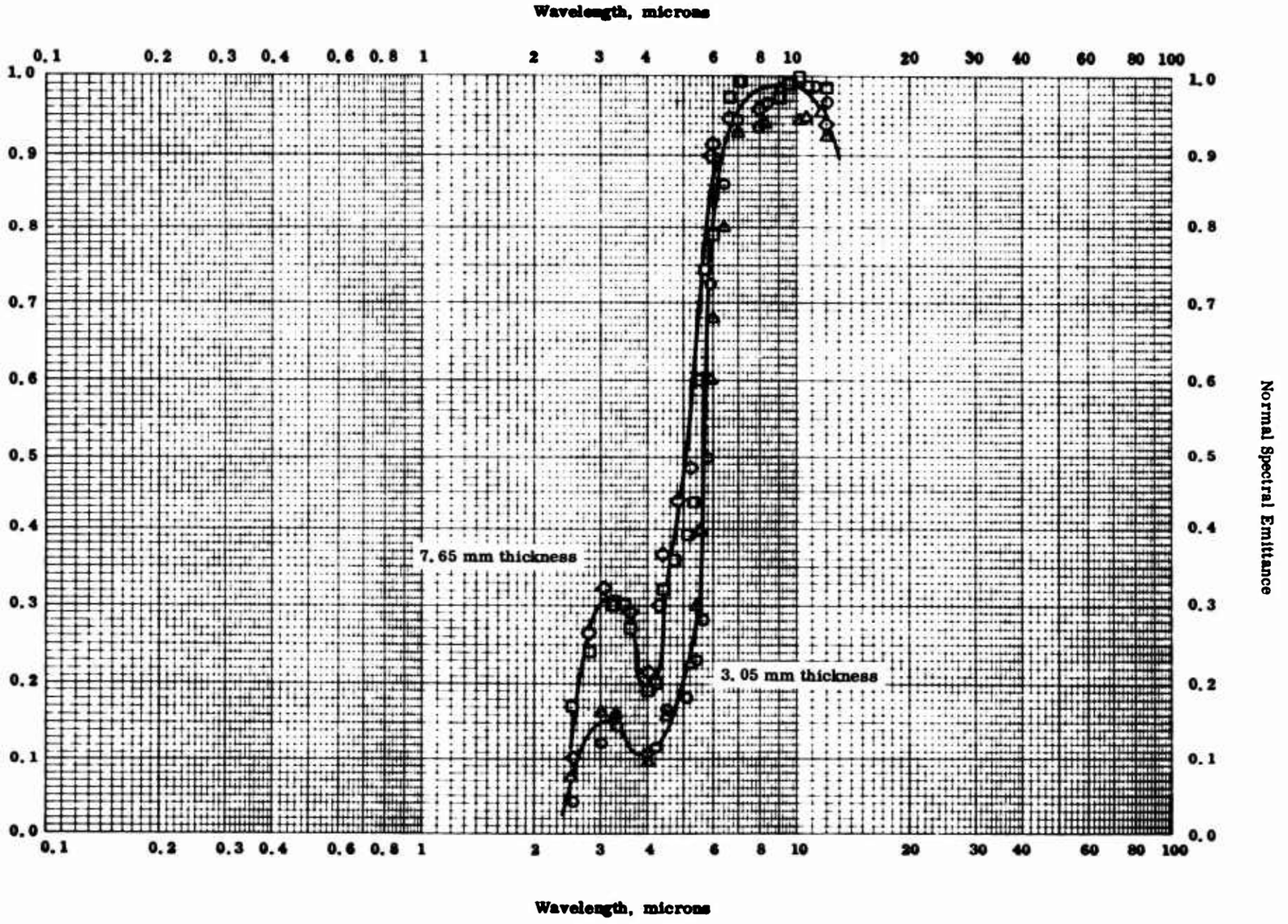


SPECIFIC HEAT -- TELLURIUM DIOXIDE

SPECIFIC HEAT -- TELLURIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-10	400-1200	0.5	Spectroscopically pure TeO_2 with only traces of Ag, Ca, Na, Si and Mn.	Sealed under argon atm.

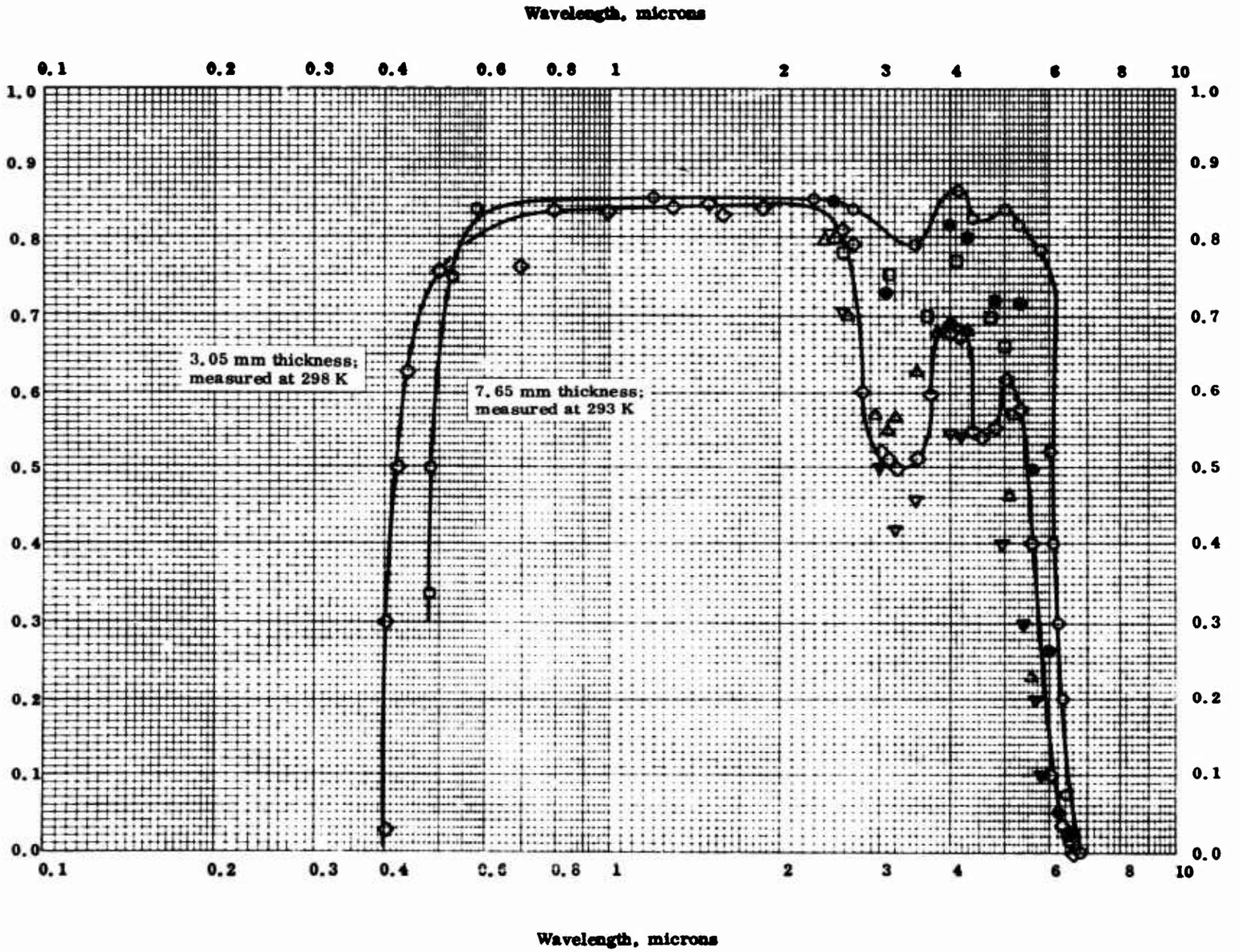


NORMAL SPECTRAL EMITTANCE -- TELLURIUM DIOXIDE

NORMAL SPECTRAL EMITTANCE -- TELLURIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	60-29	533	2.52 - 12.0		TeO_2; thickness 3.05 mm.	Pyroceram 9606 as working standard.
△	60-29	643	2.50 - 12.0		Same as above.	Same as above.
□	60-29	533	2.5 - 12.0		Same as above; thickness 7.65 mm.	Same as above.
◇	60-29	643	2.52 - 12.0		Same as above.	Same as above.

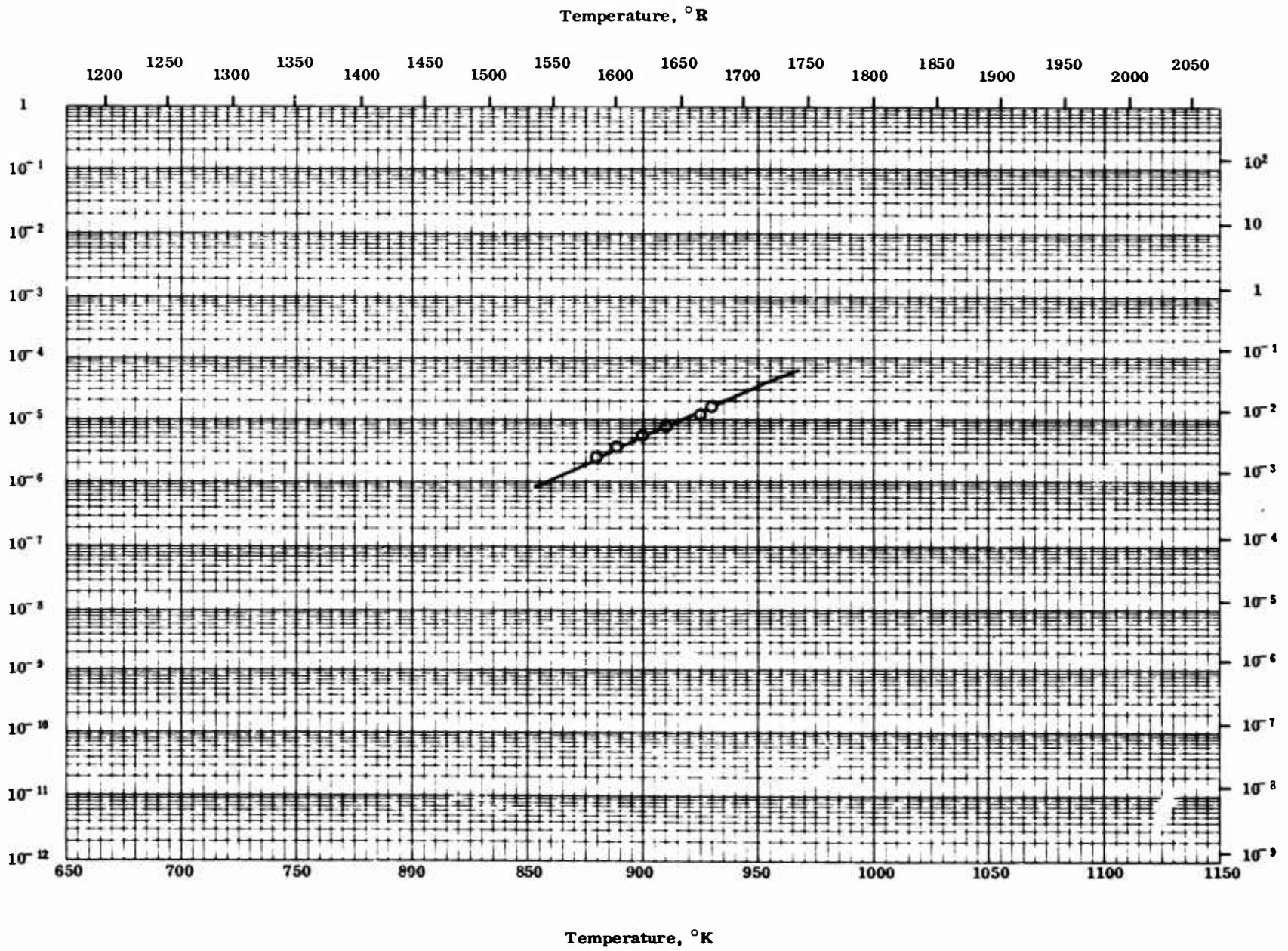


NORMAL SPECTRAL TRANSMITTANCE -- TELLURIUM DIOXIDE

NORMAL SPECTRAL TRANSMITTANCE -- TELLURIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	60-29	298	0.48 - 6.80		TeO_2; thickness 3.05 mm.	
●	60-29	533	2.5 - 7.0		Same as above.	
□	60-29	643	2.5 - 6.3		Same as above.	
◇	60-29	298	0.4 - 6.55		Same as above; thickness 7.65 mm.	
△	60-29	533	2.4 - 6.3		Same as above.	
▽	60-29	643	2.45 - 6.25		Same as above.	



TPRC

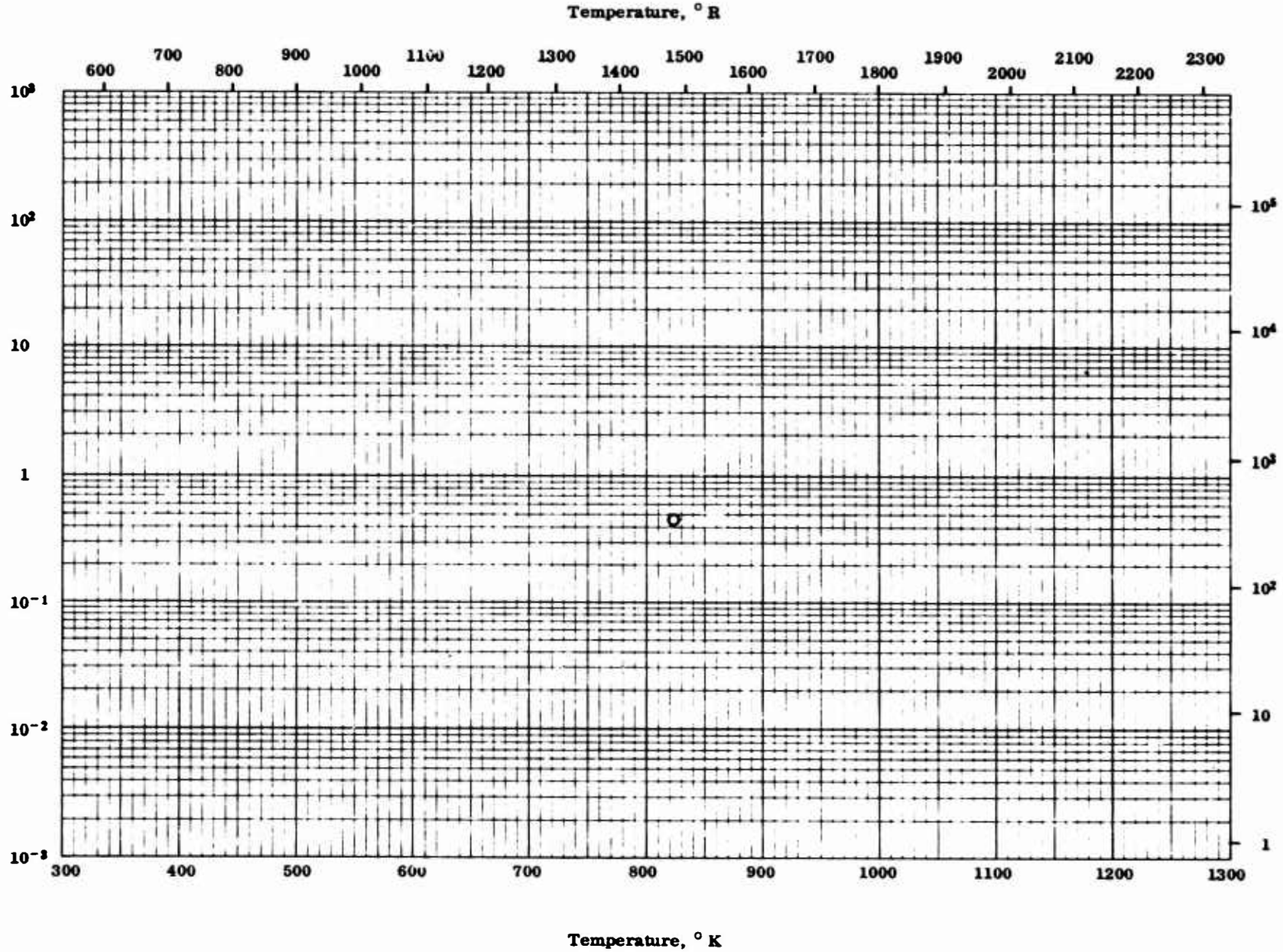
VAPOR PRESSURE -- TELLURIUM DIOXIDE

VAPOR PRESSURE -- TELLURIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	41-1	880-931		TeO_2.	

TPRC



VAPOR PRESSURE -- TERBIUM OXIDE

VAPOR PRESSURE -- TERBIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	55-12	823		$TbO_{1.818}$; face centered cubic phase.	Determined by x-ray photograph.

PROPERTIES OF THORIUM DIOXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	10	624
Melting Point	3540	6370
Heat of Sublimation	647_{2150K}	1165_{3870R}

REPORTED VALUES

Density	g cm^{-1}	lb ft^{-1}
●	8.65	540
■	9.55	596
▲	10.01	625
▼	9.70	606
◀	9.75	609
▶	9.820	613.0
◆	9.68	604
◐	8.3	520
◧	6.58	411
▲	10.0	624
▼	8.9 ± 0.1	556 ± 6
◀	7.5	468
▶	7.5	468
◁	7.55 ± 0.35	471 ± 22
▷	8.6	537
◐	8.0	499
◧	9.715 ± 0.015	606.5 ± 0.5
▲	9.82	613

Melting Point	K	R
△	3273	5892
◇	3543	6378
▼	3493 ± 50	6287 ± 90

PROPERTIES OF THORIUM DIOXIDE

REPORTED VALUES

Heat of Sublimation	cal g^{-1}	Btu lb^{-1}
○	644.8_{298K}	1161.0_{537R}
□	647_{2150K}	1165_{3870R}
▽	547.1_{2828K}	984.8_{5090R}

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-14	298		Pure.	Δh_s from vapor pressure data.
□	52-6	2050-2250		99 ThO_2.	Same as above.
△	49-3	3273		ThO_2.	
◇	56-20	3543		ThO_2.	
▽	56-4	2828		ThO_2.	Δh_s from vapor pressure data.
●	56-21	298		99.9 ThO_2.	Pressed at 10,000 psi.
■	56-21	298		99.9 ThO_2.	Pressed at 5000 psi, heated 5 hrs at 1000 C, and repressed at 1000,000 psi.
◭	56-21	298		99.9 ThO_2.	Density by x-ray measurements.
▼	56-21	298		99.5 ThO_2 and 0.5 CaO.	Pressed at 10,000 psi.
◮	56-21	298		Same as above.	Pressed at 5000 psi, heated 5 hrs at 1000 C, and repressed at 100,000 psi.
▶	56-21	298		Same as above.	Density computed from x-ray measurements.
▼	52-15	3443-3543		99.7 ThO_2.	M. P. from visual observation.
◆	50-11	298		ThO_2; made from oxalate containing 0.01 >each Mg, Pb, and Zn, 0.01 > each Ca, Cu, and Si.	Oxalate calcined at 1000 C for 1 hr, heated to 1100 C in 20 min, and then fired either 2 min at 2300 C or 10 min at 1900 C; density from x-ray measurements.
◐	50-11	298		Same as above.	Same as above.

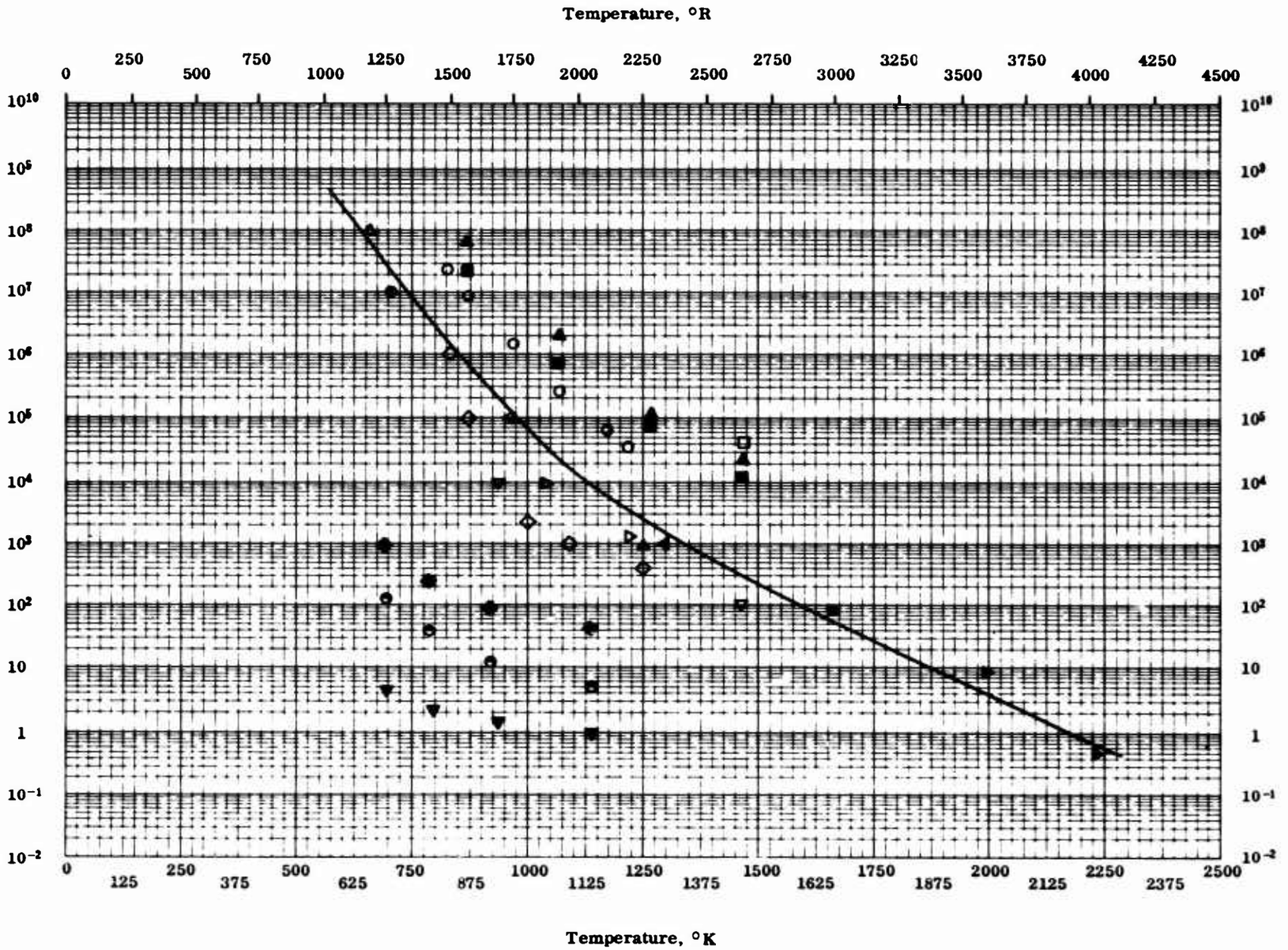
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PROPERTIES OF THORIUM DIOXIDE (continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◘	50-11	298		Same as above.	Same as above, but also pressed at 52,000 psi.
▲	55-32	298		ThO_2.	Molded at 18,000 psi; computed from x-ray measurements of lattice.
▼	55-32	298		ThO_2.	Molded at 18,000 psi, fused 1 hr at 1800 C from 0-5μ particles; density by weight in air and in Hg.
◀	55-32	298		ThO_2.	Same as above, but particles 10-15μ.
▶	55-32	298		ThO_2.	Same as above, but particles 30-40μ.
◁	55-32	298		ThO_2.	Same as above, but mixture of particle sizes.
▷	55-32	298		2 TiO_2.	Same as above, but particle size 10-15μ.
○	55-32	298		2 Fe_2O_3.	Same as above.
◘	55-32	298		0.5 CaO.	Density by weight in air and in Hg.
▲	55-32	298		0.5 CaO.	Density from x-ray measurement of lattice.

TPRC



ELECTRICAL RESISTIVITY -- THORIUM DIOXIDE

ELECTRICAL RESISTIVITY -- THORIUM DIOXIDE

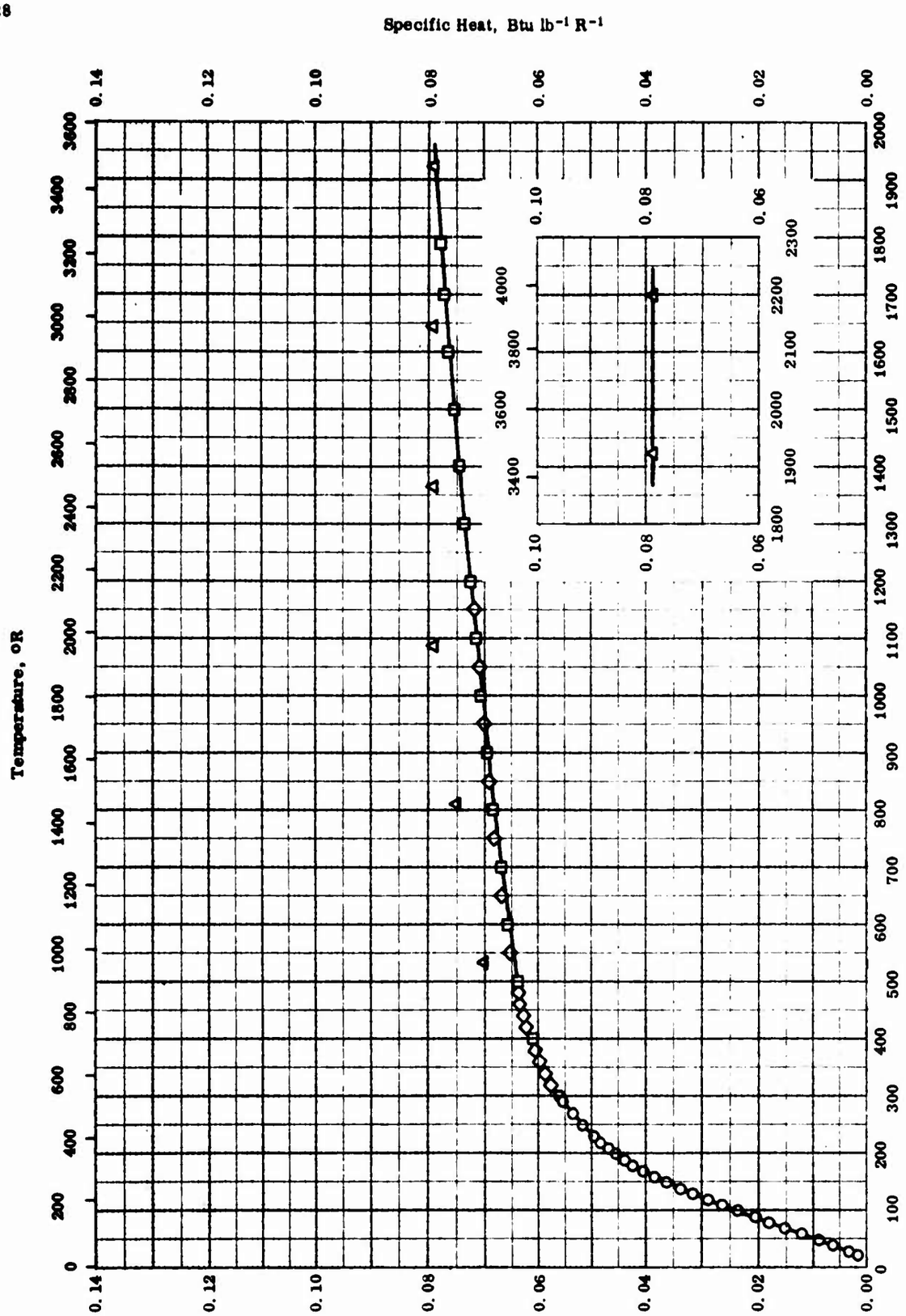
REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	40-3	828-1218		ThO_2; 1 cm cube samples.	Platinized end faces; author est. accuracy only order of magnitude.
□	49-3	1473-2073		ThO_2.	
△	54-23	658-1250		ThO_2; 0.01 Al, La, and traces of Cr, Cu, Si, Be, Ti, Ce, Y, and Zr.	In H_2 and He atmosphere.
◇	54-23	833-1250		Same as above.	In O_2 atmosphere.
▽	54-23	935-1471		Same as above.	Measured in O_2 at 760 mm Hg.
▷	54-23	1042-1250		Same as above.	Measured in O_2 at 0.37 mm Hg.
◁	54-23	962-1299		Same as above.	Measured in O_2 at 0.000002 mm Hg.
●	56-16	705-1667		ThO_2.	Arc fused, cut into parallelepipeds; measured under 10^{-6} mm Hg; resistance R by equation: $i = \frac{V}{R} e^{-\left(\frac{t}{RC}\right)}$
■	42-5	873-1473		Very pure ThO_2; porosity 24% and density 487 lb ft^{-3}.	Pressed at 3000 kg cm^{-2} and calcined at 2100 C; $r = Ae^{\left(\frac{B}{T}\right)}$ where A, B = const. and T = absolute temp; measured in air.
▲	42-5	873-473		Same as above.	Same as above, except measured in vacuum; author also reports measurements in other atm.
▼	50-8	695-1134		ThO_2; density 437 lb ft^{-3}.	r varies as current density J; meas. in vacuum; J = 7.6 amp cm^{-2}.

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REFERENCE INFORMATION

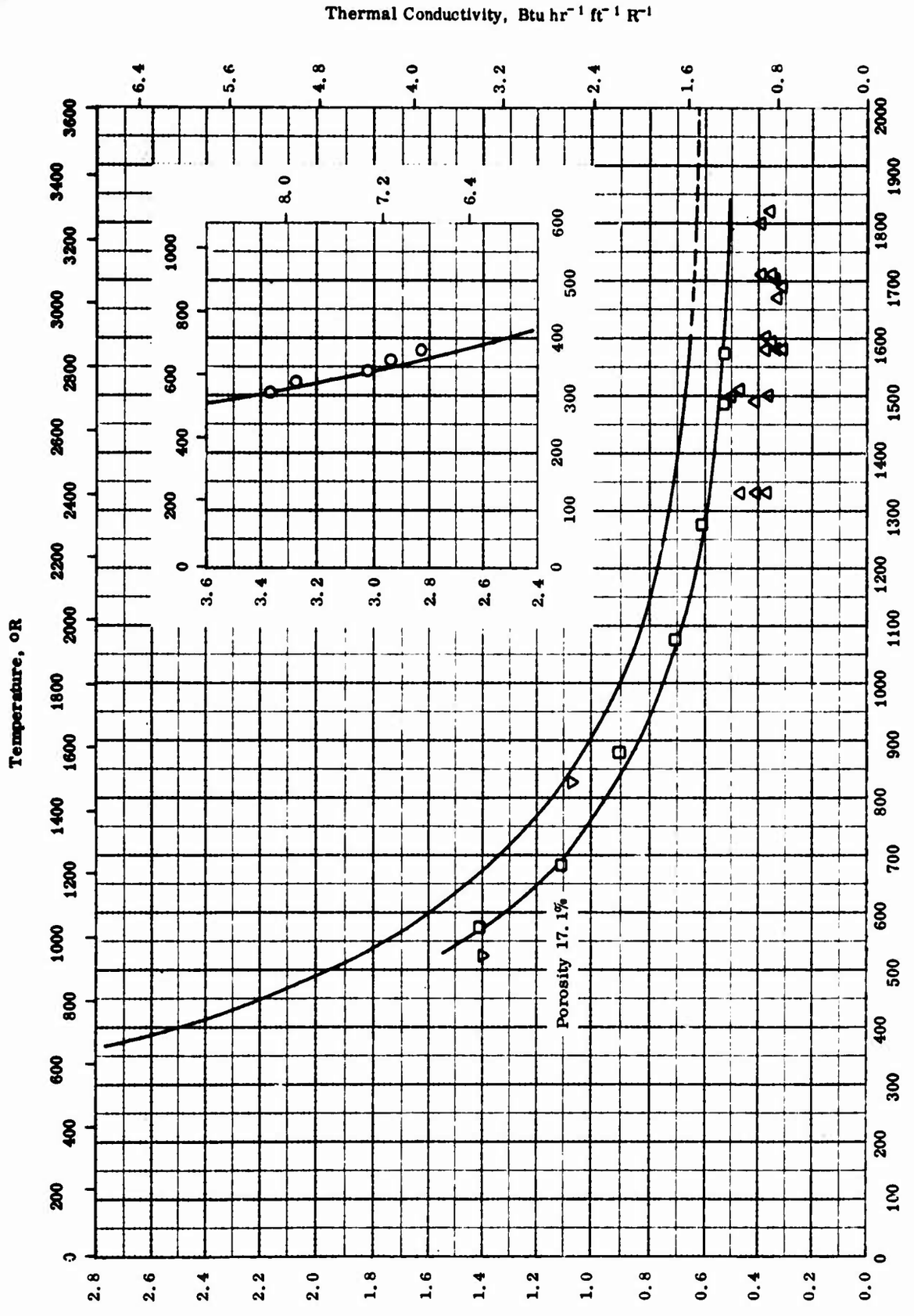
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
⊖	50-8	695-1134		Same as above.	Same as above except J = 0.76 amp cm^{-2}.
◆	50-8	695-1134		Same as above.	Same as above, except J = 0.076 amp cm^{-2}.
▶	62-4	1994-2230	2.4	ThO_2.	Pressed and sintered; maximum exposure temperature 4000 F.



SPECIFIC HEAT -- THORIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-12 also 53-13	10-305		ThO_2; 0.015 max. rare earths, 0.005 each Al and Si, 0.004 La, and 0.005 > others.	
□	41-2	298-1790	0.50	99.28 ThO_2, 0.26 common metals, and 0.46 rare earths.	
△	62-4	533-2200	≤5.0	ThO_2; density 568 lb ft^{-3}.	Crushed in hardened steel mortar to pass 100-mesh screen; pressed and sintered.
◇	61-19	298-1200	0.3-0.5	99.95 ThO_2, 0.01 Al, 0.005 Ca, 0.005 Cu, 0.004 Fe, 0.001 > B, and 0.0005 > Cr; density 605 lb ft^{-3}.	Pressed; fired and sintered.

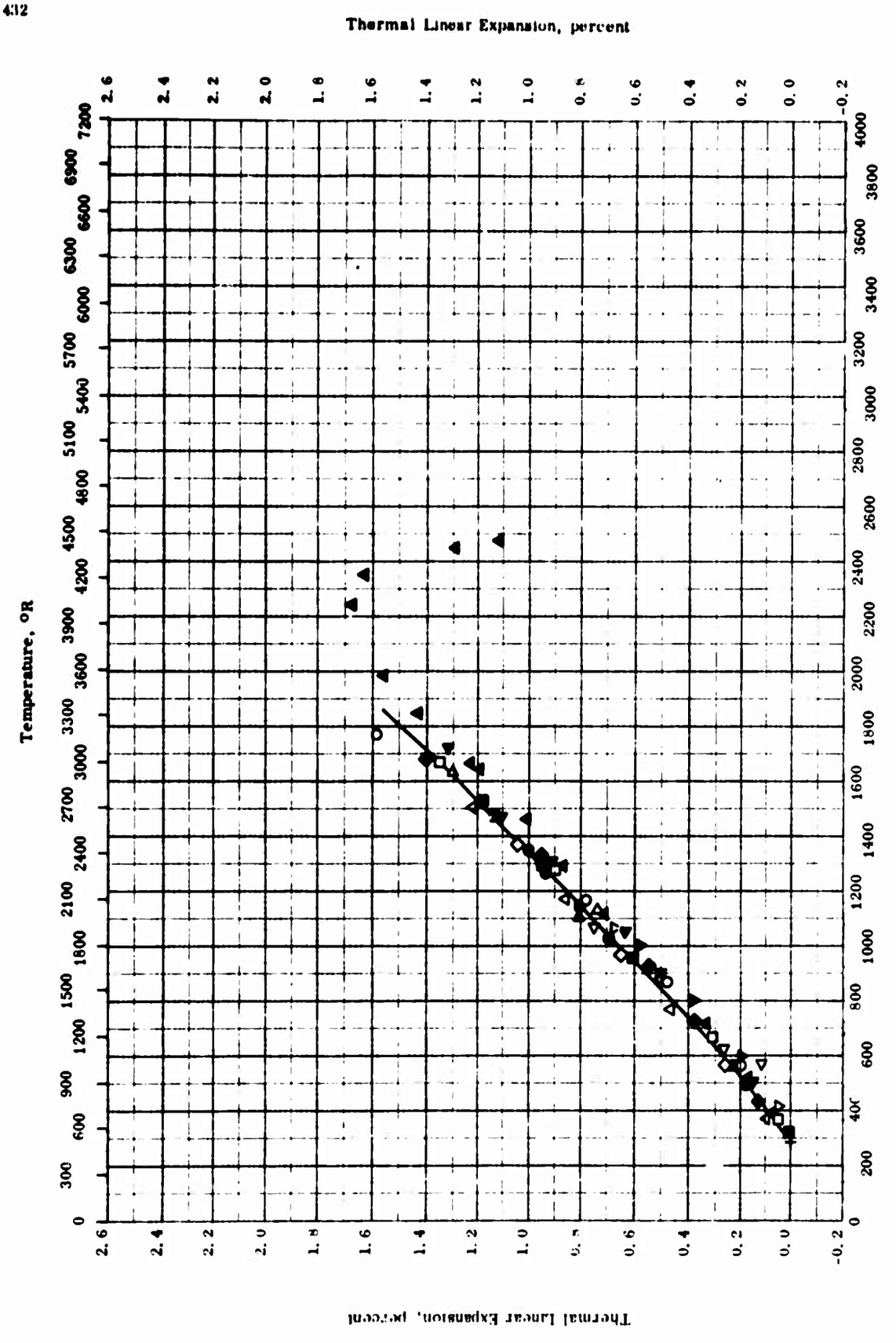


THERMAL CONDUCTIVITY -- THORIUM DIOXIDE

THERMAL CONDUCTIVITY -- THORIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Repl. Error %	Sample Specifications	Remarks
O	53-1	306-379		Spectroscopically pure; density 598 lb ft^{-3}.	Hot pressed at 1790-1820 C; tested in vacuum.
□	54-6	573-1573		Density 504 lb ft^{-3}; total porosity 16.7%.	Slip cast from suspension of finely ground material.
△	62-4	1331-1821	5-7	ThO_2.	Ground and polished thoroughly; sample found broken on post inspection.
▽	57-7	527-824		0.5 CaF_2; average bulk density 9.37 g cm^{-3}.	Hot pressed at 1500 + 50 C and at a pressure of ca 100 psi for 30 min.



THERMAL LINEAR EXPANSION -- THORIUM DIOXIDE

THERMAL LINEAR EXPANSION -- THORIUM DIOXIDE

REFERENCE INFORMATION

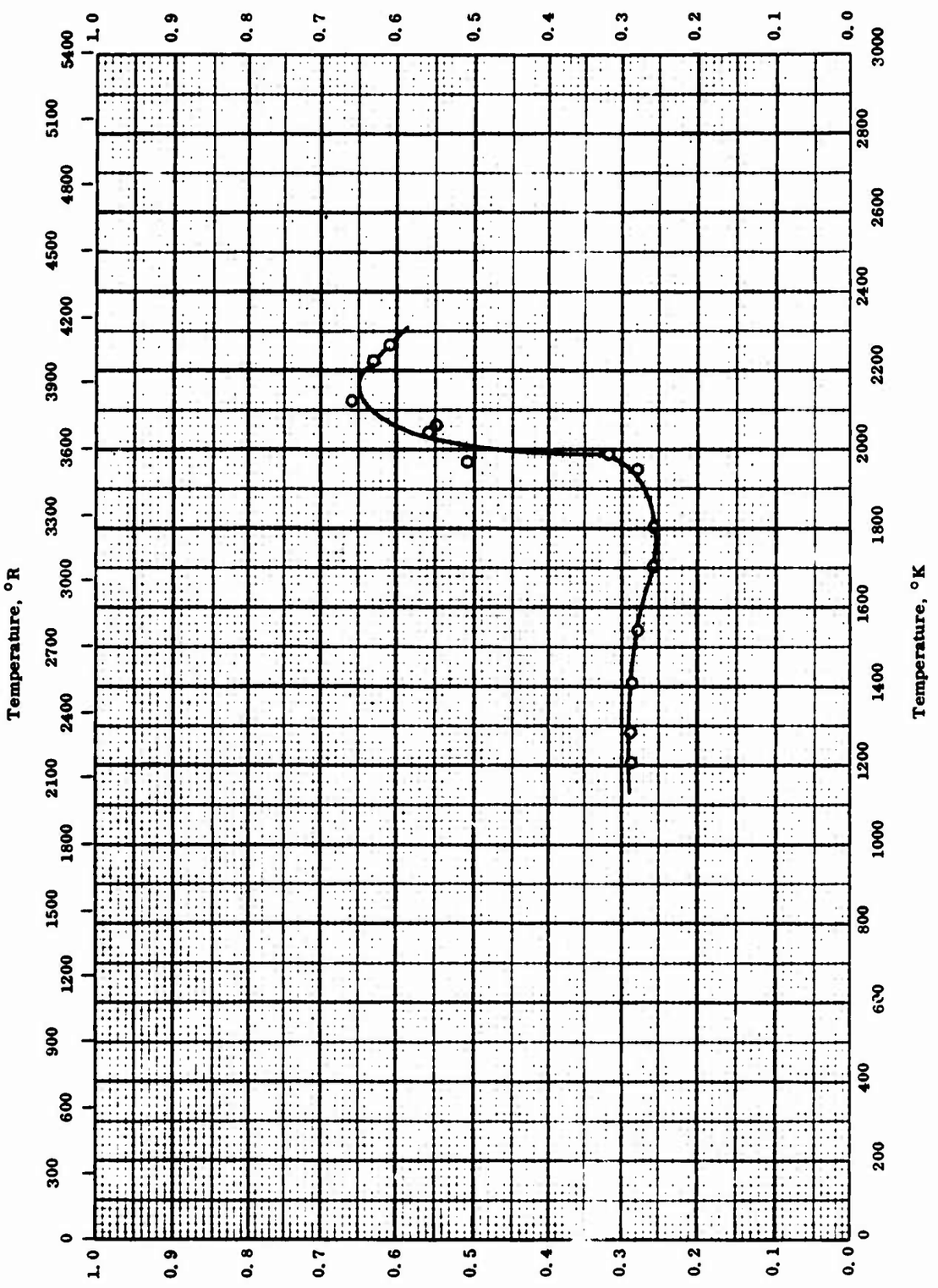
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
●	62-28	300-1354	2-3	99.9 ThO_2, 0.003 - 0.03 Al and Si, 0.001 - 0.01 Ca and Fe, and trace of Mg; cubic.	Mixture of ThO_2 with approx. 40 Pt ground to a fine powder, heated with a gas-oxygen torch for 15 min and cooled to room temperature; Pt powder used for furnace alinement and thermal calibration; x-ray diffractometer method.
▲	62-4	294-2478	5	ThO_2 from Zirconium Corp. of Am.; density at 25 C by ASTM method B311-58 before exposure 9.10 g cm^{-3}; initial length 2.880 in., final length 2.850 in. [Author's design : Run No. E 19]	Pressed and sintered; measured in helium atm.
■	63-40	296-1533		ThO_2.	Percent expansion calculated from a_o lattice parameters.
○	56-28	573-1773		Fine fused grain ThO_2.	
□	56-21	303-1673		ThO_2; 0.5 CaO.	Data to 800 C checked with interferometer.
△	57-40	293-1503		ThO_2; 1 CaO.	Fired at 1800 C.
◇	57-40	293-1373		ThO_2; 75% theoretical density.	Fired at 1800 C.
▽	57-39	298-1073	±0.2	ThO_2; 0.1 - 0.5 Si and Mg, 0.01 - 0.05 Fe, B, and Al, 0.001 - 0.005 Sc and Cu, and 0.0001 - 0.0005 Be.	X-ray diffraction method.
▼	57-41	293-1723		Pure ThO_2.	Dry mixed, pressed at 1000 Kg cm^{-2}, fired to 1700 C in 5-1/2 hrs, held 1 hr, and cooled overnight; plotted data are average of author's heating and cooling curves.

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THERMAL LINEAR EXPANSION -- THORIUM DIOXIDE (continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◆	55-37	273-1677		ThO_2; 0.001 - 0.01 Al and 0.0001 - 0.001 each Ag, Ca, Cu, and Mg.	X-ray diffraction method.
◁	55-38	303-1073		99.5 ThO_2 and 0.5 CaO; density 606 - 607 lb ft^{-3}.	Dry pressed (no binder) at 3000 psi and pressed 1 hr at 1800 C under 30,000 psi in oxidizing atm.
▷	55-32	303-1633		99.5 ThO_2 and 0.5 CaO.	Pressed sample heated and pressed 1 hr at 1800 C under 30,000 psi.
▶	55-32	303-1103		Same as above.	Same as above.

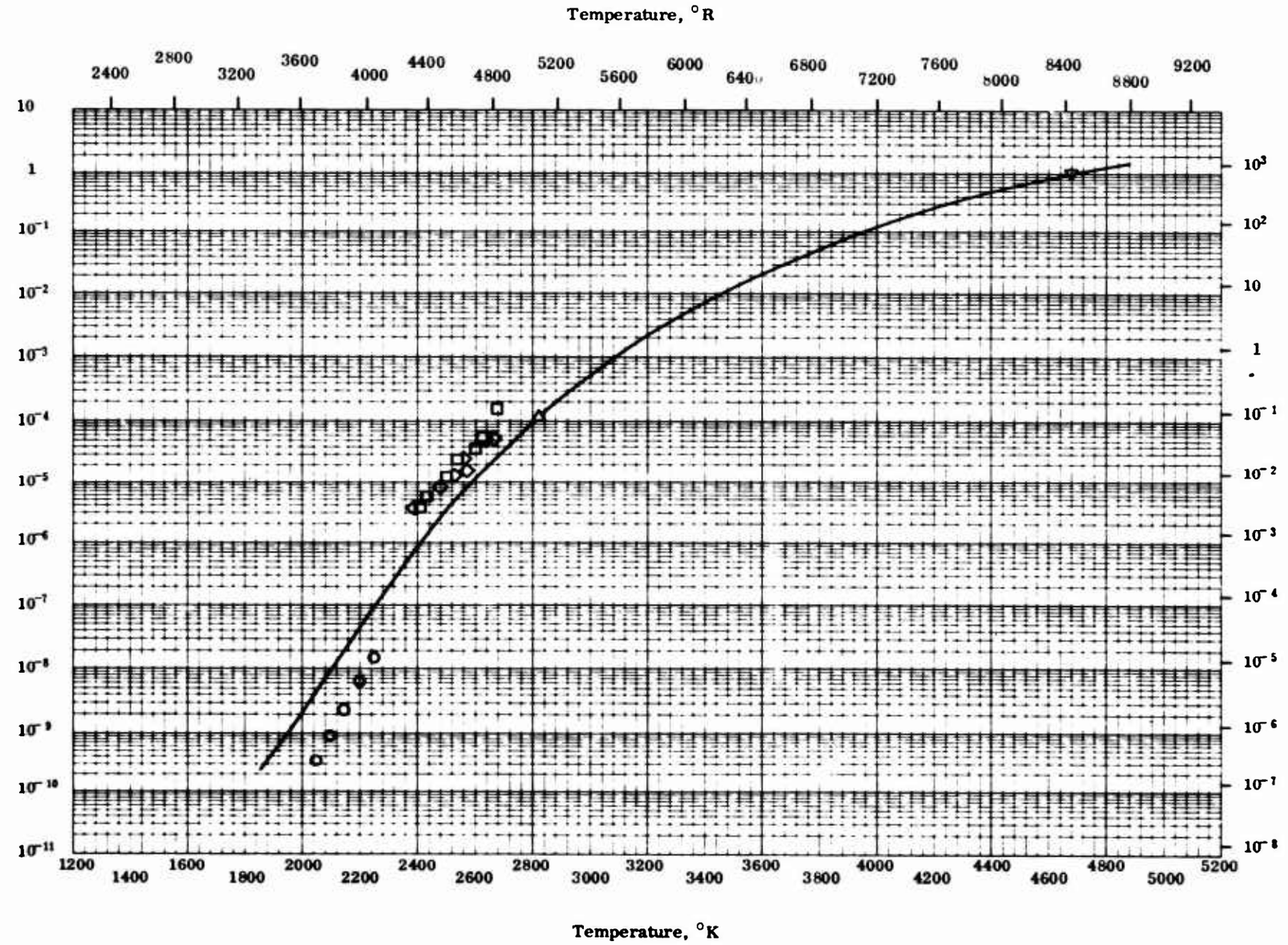


NORMAL TOTAL EMITTANCE -- THORIUM DIOXIDE

NORMAL TOTAL EMITTANCE -- THORIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	62-4	1212-2265	10	ThO_2; density 9.69 g cm^{-3}.	Pressed and sintered; measured in dry argon atmosphere.

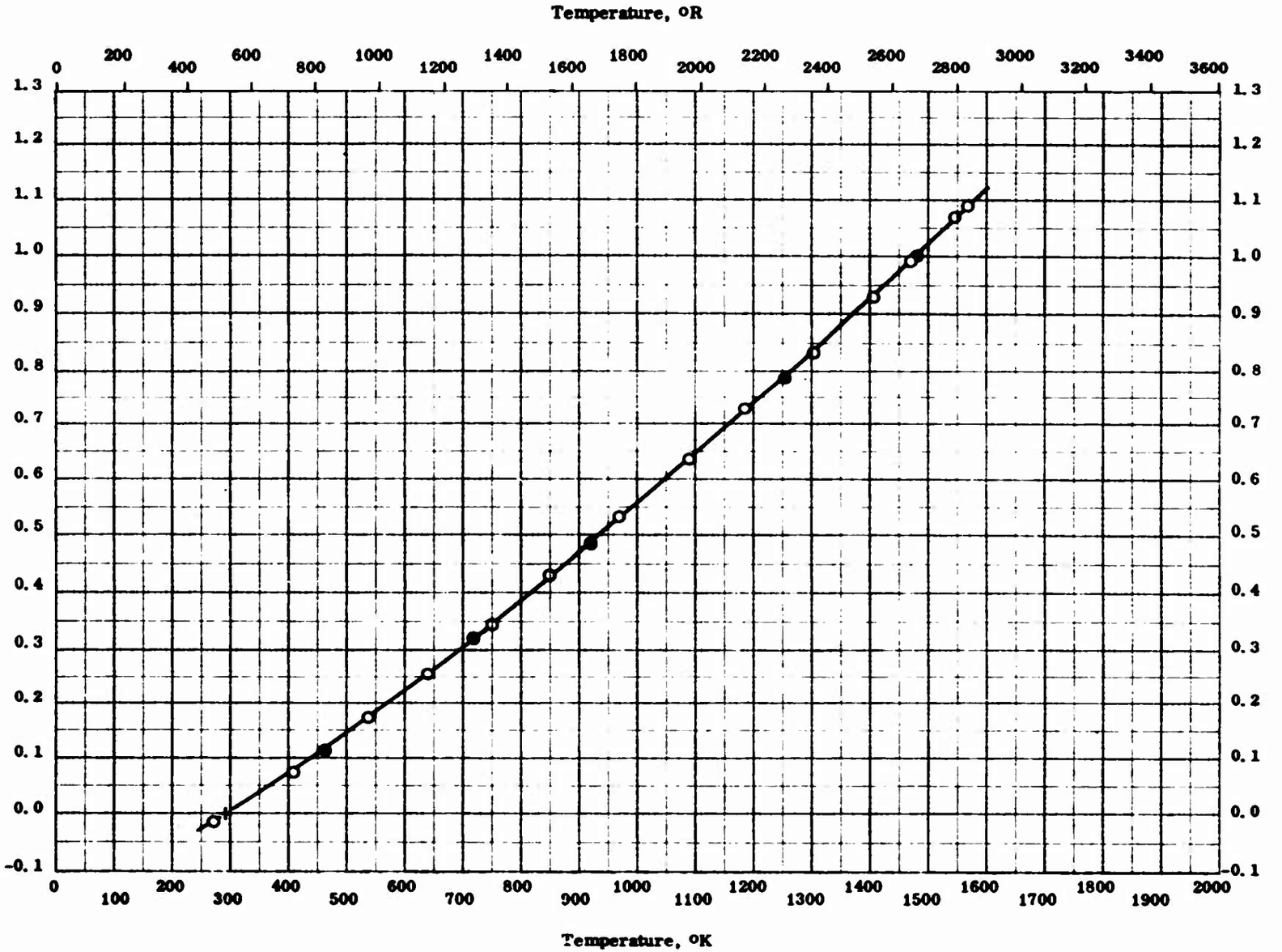


VAPOR PRESSURE -- THORIUM DIOXIDE

VAPOR PRESSURE -- THORIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-6	2050-2250		99 pure ThO_2.	W wire coated with ThO_2.
□	54-13 also 54-14	2398-2676		"Pure" ThO_2.	Ta cell degassed for 2 hrs before each run; corrected for evaporation of cell (ca 10%).
△	56-4	2828		ThO_2.	W cell.
▽	49-3	4673		ThO_2.	
◇	54-14	2389-2661		ThO_2.	Corrected for evaporation of Ta cell material and for thermal expansion of orifice; authors suspect major error in temp. measurement leading to high values for density.



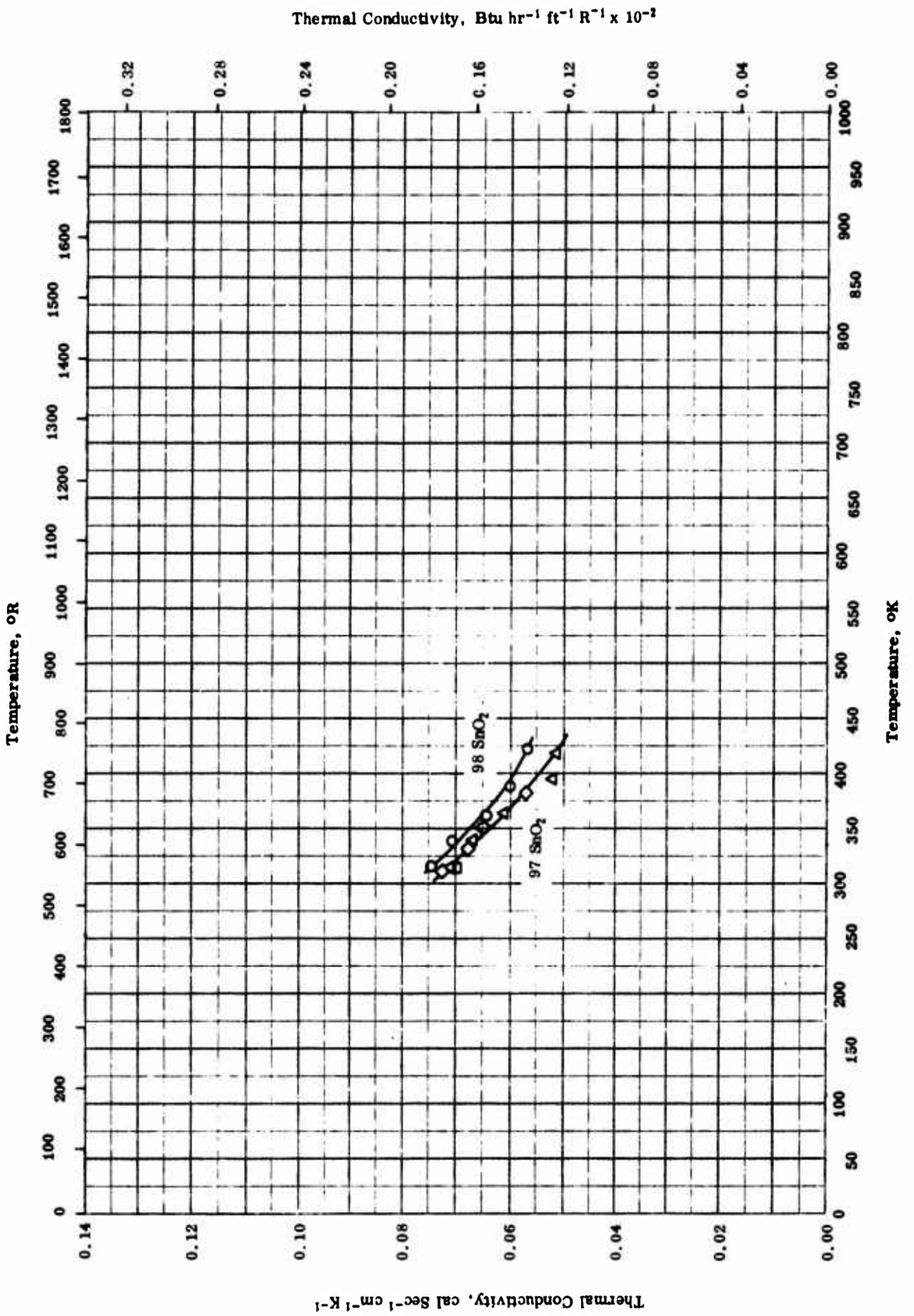
TPRC

THERMAL LINEAR EXPANSION -- THULIUM OXIDE

THERMAL LINEAR EXPANSION -- THULIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-41	273-1568	1.1-6.0	Tm_2O_3, code 1405 from Lindsay Chemical Co., West Chicago, Ill.; 99.9 Tm_2O_3 in regard to total rare-earth content; 0.01-0.1 Ca, 0.003-0.03 Si, 0.001-0.01 Yb, and trace of Lu, Mg, Pb, and Y; cubic, rare-earth oxide type C.	Sintered at 1200 C for 24 hrs, packed into alumina sample holder, resintered at 1300 C for 12 hrs, cooled to 400 C, and placed in a vacuum desiccator for storage; x-ray diffractometer method.
●	61-41	463-1568	1.1-6.0	Same as above.	Cooling cycle for above sample.

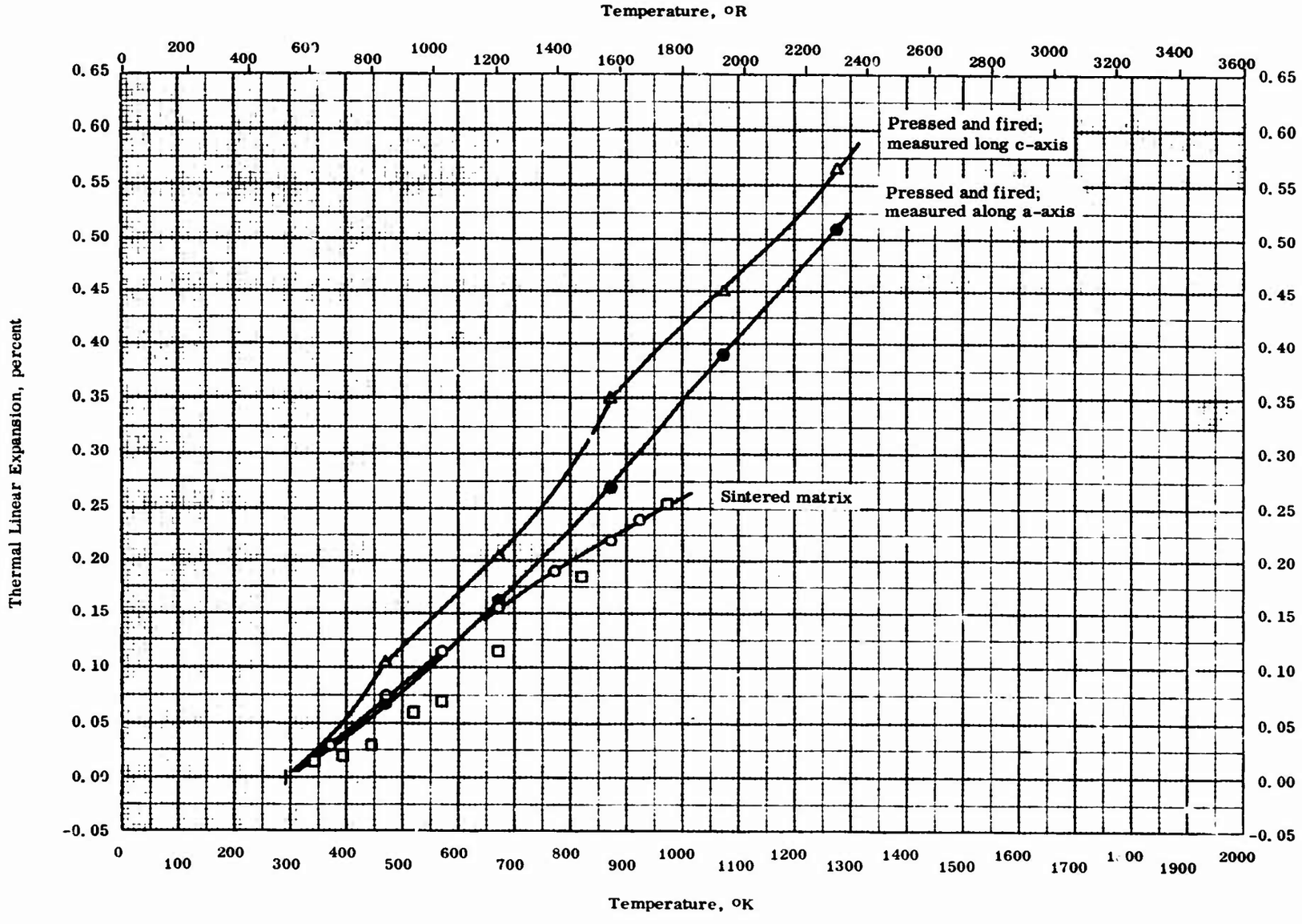


THERMAL CONDUCTIVITY -- TIN(IC) OXIDE

THERMAL CONDUCTIVITY -- TIN(IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-5	315-423		98 SnO_2; impurities not given; density 406 lb ft^{-3}.	Fired 1 hr. at 2600 F; tested in vacuum.
□	54-7	313.4	±5	97 SnO_2 (approx.) 0.1 - 1.0 Si, 0.9 ZnO; 0.05 - 0.50 Fe, 0.01 - 0.10 Ca, and others < 0.01; apparent porosity 2.6%.	Sintered matrix.
△	53-1	311-422		98 SnO_2, density 413 lb ft^{-3}.	Furnished by Metal and Thermit Corp.
◇	53-1	311-383		98 SnO_2, density 410 lb ft^{-3}.	Same as above.



THERMAL LINEAR EXPANSION -- TIN (IC) OXIDE

THERMAL LINEAR EXPANSION -- TIN (IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
●	62-36	296-1273		SnO_2.	Ball-milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15 binder (40 g Carbowax 20 M, 20 cc of 2% Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disk about 1/4 in. thick, fired to 1000 C for 16 hrs, cooled to room temperature in less than 30 min, and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
△	62-36	296-1273		SnO_2.	Same as above except measured along c-axis.
○	54-7	293-923		97 SnO_2, 0.9 ZnO, 0.1 - 1.0 Si, 0.05 - 0.5 Fe, 0.01 - 0.1 Ca, and < 0.01 others; apparent porosity 0.4%.	Sintered matrix.
□	46-6	293-973		SnO_2.	

PROPERTIES OF TITANIUM OXIDES

MOST PROBABLE VALUES

Property	C.G.S. Units *	Brit. Eng. Units *
Density.	4.0	250
Melting Point	2113	3804
Heat of Sublimation	2175_{298K}	3920_{536R}

* For TiO_2 only.

REPORTED VALUES

Density	g cm^{-3}	lb ft^{-3}
○ TiO_2	3.904 ±0.002	243.7 ±0.1
□ TiO_2	4.150 ±0.002	259.1 ±0.1
✱ TiO_2	3.66	228
⊃ TiO_2	3.92	244
▲ TiO_2	3.83	239
▼ TiO_2	3.66	228
◀ TiO_2	3.85	240
▶ TiO_2	3.90	243
◆ TiO_2	2.59	161
● TiO_2	2.64	164
■ TiO_2	3.34	208
◁ TiO_2	2.52	157
▷ TiO_2	2.54	158
▲ TiO_2	4.01 ±0.01	250.3 ±0.6
Melting Point	**K**	**R**
△ TiO_2	1993	3588
◇ TiO_2	2113 ±10	3804 ±18
◐ TiO_2	2113 ±10	3804 ±18
◧ TiO_2	2113 ±15	3804 ±27
▲ TiO_2	2133 ±15	3839 ±27
▼ TiO_2	2143 ±15	3857 ±27
◀ TiO_2	2143 ±15	3857 ±27
▶ TiO_2	2143 ±15	3857 ±27
◆ TiO_2	2103	3785

PROPERTIES OF TITANIUM OXIDES (continued)

REPORTED VALUES

Heat of Sublimation		cal g^{-1}	Btu lb^{-1}
▽	TiO_2	$1738_{0K} \pm 6$	$3129_{0R} \pm 10$
▼	TiO	$2106_{0K} \pm 8$	$3790_{0R} \pm 15$
◀	TiO_2	$2175_{298\,K} \pm 78$	$3920_{536\,R} \pm 140$
▶	TiO	$1830_{298\,K} \pm 60$	$3290_{536\,R} \pm 110$

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	56-8	298		TiO_2, anatase; x-ray showed only anatase lines; prepared by doubly distilled clear and colorless $TiCl_4$ practically free of Fe.	Synthetically prepared, precipitated with ammonia, washed, and heated 4 hrs at 565 C.
□	56-8	298		TiO_2, rutile; x-ray showed no anatase lines; prepared by doubly distilled clear and colorless $TiCl_4$ practically free of Fe; material white with slight yellow cast.	Synthetically prepared, precipitated with ammonia, washed, dried, pulverized and heated 1-1/2 hrs at 930 C, and pulverized and reheated several hrs
△	51-14	1993		TiO_2, very pure single crystal of rutile and anatase.	M. P. by visual observation and 6 C corrected for absorption by Vycor window in furnace.
◇	52-13	2103-2123		TiO_2, rutile with only trace of anatase; several samples of specially pure oxide (0.04 Si, 0.02 Mg, and 0.01 Ca) and c.p. reagent grade (0.04 H_2O soluble salts, 0.001 each Zn and Pb, and 0.00001 As).	M. P. by observing collapse of the cone in oxidizing atm.
▽	55-13	0		"Bakers Analyzed" c.p. grade TiO_2; 0.04 water soluble salts, 0.01 Pb, 0.003 Fe, and 0.002 Zn.	Δhs from vapor pressure measurement.
▼	55-13	0		TiO; prepared from TiO_2 and iodide Ti (containing 0.02 N_2, Te, Cu, and Pb, 0.0082 Mn, 0.007 Si, and 0.0066 Al).	Δhs from vapor pressure data.
◀	56-3 also 57-10	298		TiO_2.	Same as above.
▶	56-3 also 57-10	298		TiO.	Same as above.

(Continued onto next page)

PROPERTIES OF TITANIUM OXIDES (continued)

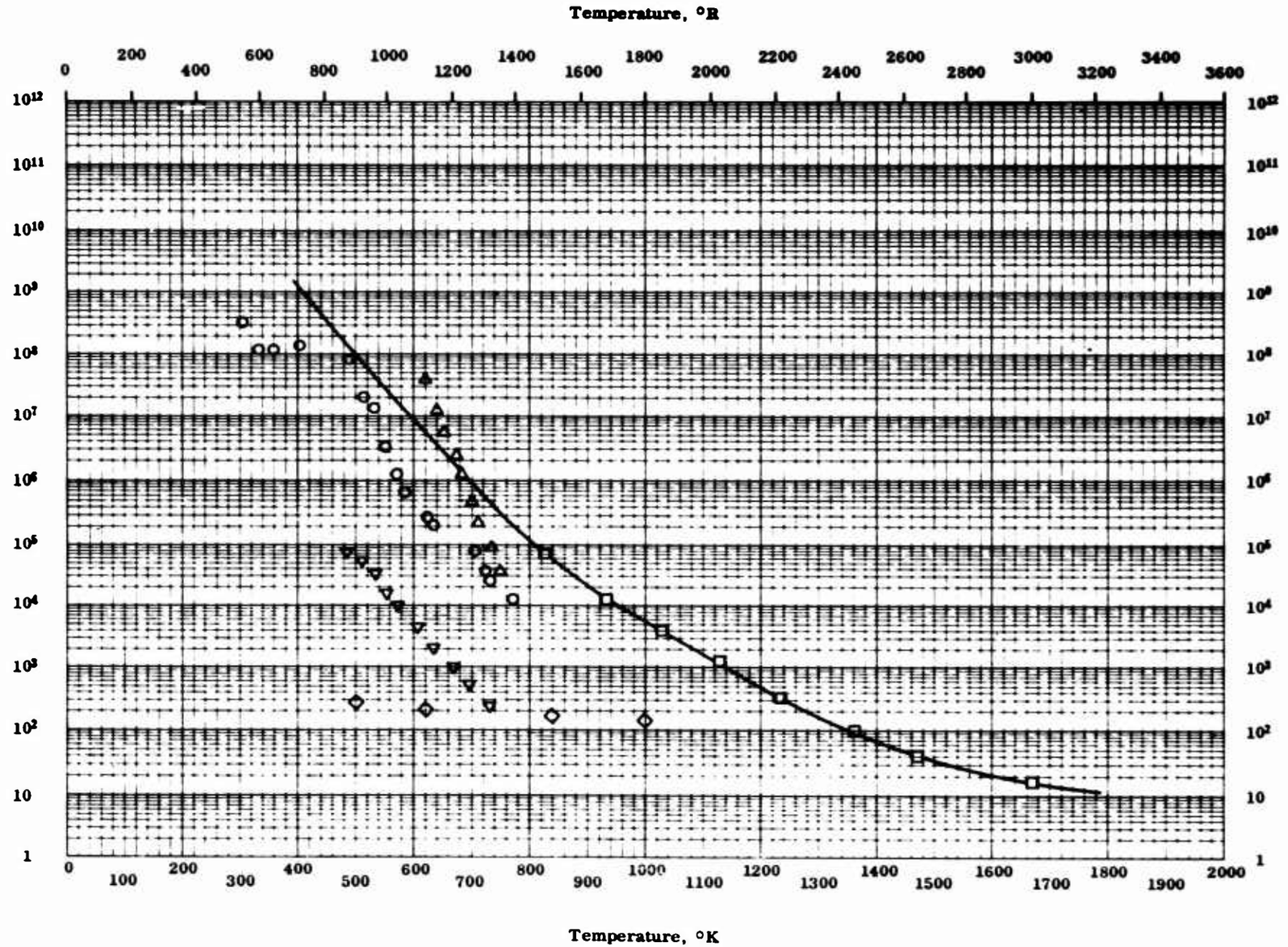
REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
●	49-6	298		98.7 TiO_2, 0.93 SiO_2, and 0.40 Fe_2O_3; porosity 9.9%; dry bulk density 161 lb ft^{-3} (unfired).	Dust pressed, partially dried, granulated, dried, pressed at 10,000 psi, and fired at 1500 C.
■	49-6	298		Same as above except porosity 6.1%.	Same as above.
▲	49-6	298		98.7 TiO_2, 0.93 SiO_2, and 0.40 Fe_2O_3; porosity 6.5%; dry bulk density 160 lb ft^{-3} (unfired).	Same as above.
▼	49-6	298		Same as above except porosity 9.5% and dry bulk density 166 lb ft^{-3} (unfired).	Same as above.
◀	49-6	298		Same as above except porosity 6.0% and unfired dry bulk density 162 lb ft^{-3}.	Same as above.
▶	49-6	298		Same as above except porosity 10.6%.	Same as above.
◆	49-6	298		Same as above except porosity 37.9% and unfired dry bulk density 152 lb ft^{-3}.	Same as above except partially reduced to sub-oxides in graphite-resistor load-test furnace and held 3 hrs at 1500 C.
◐	49-6	298		Same as above except porosity 37.6%.	Same as above.
◨	49-6	298		Same as above except porosity 21.0% and unfired dry bulk density 161 lb ft^{-3}.	Same as above.
◁	49-6	298		Same as above except porosity 39.4% and unfired dry bulk density 154 lb ft^{-3}.	Same as above.
▷	49-6	298		Same as above except porosity 40.8% and unfired dry bulk density 155 lb ft^{-3}.	Same as above.

(Continued onto next page)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▲	57-13	298		TiO_2.	Density by weight in water and in kerosene.
●	60-23	2103-2123		~99.9 pure.	Measured in air.
■	60-24	2098-2128		>99.8 pure.	Measured in O_2 at 300 torr and A at 460 torr.
▲	60-24	2118-2148		Same as above.	Measured in O_2 at 500 torr and A at 260 torr.
▼	60-24	2128-2158		Same as above.	Measured in O_2 at 600 torr and A at 160 torr.
◀	60-24	2128-2158		Same as above.	Measured in O_2 at 760 torr.
▶	60-24	2128-2158		Same as above.	Measured in O_2 at 1140 torr.
◆	59-12	2103			



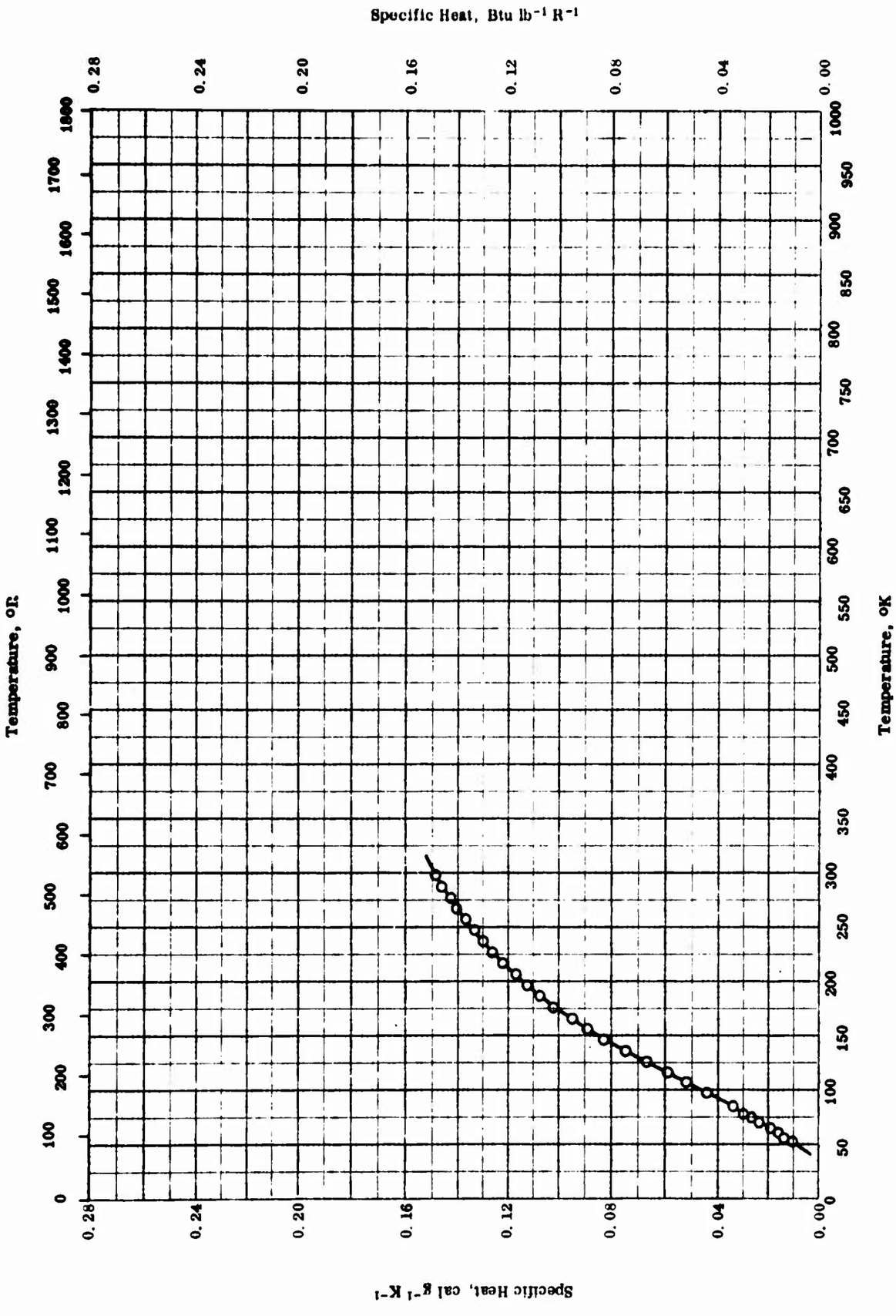
TPRC

ELECTRICAL RESISTIVITY -- TITANIUM DIOXIDE

ELECTRICAL RESISTIVITY -- TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-20	303-588		Chemically pure TiO_2; rutile.	Heating.
△	53-20	303-588		Same as above.	Cooling.
□	53-17	823-1673		TiO_2.	Fired 24 hrs to 1450 C.
▽	64-7	873-1316		TiO_2; rutile; 0.01 Ba, 0.001-0.001 Al, Mg, and Pb, and traces of Ag, Cu, Ca, and Fe; single crystal.	Sample axis approximately parallel to c-axis; measured in air.
◇	60-3	500-1000		Reduced TiO_2.	

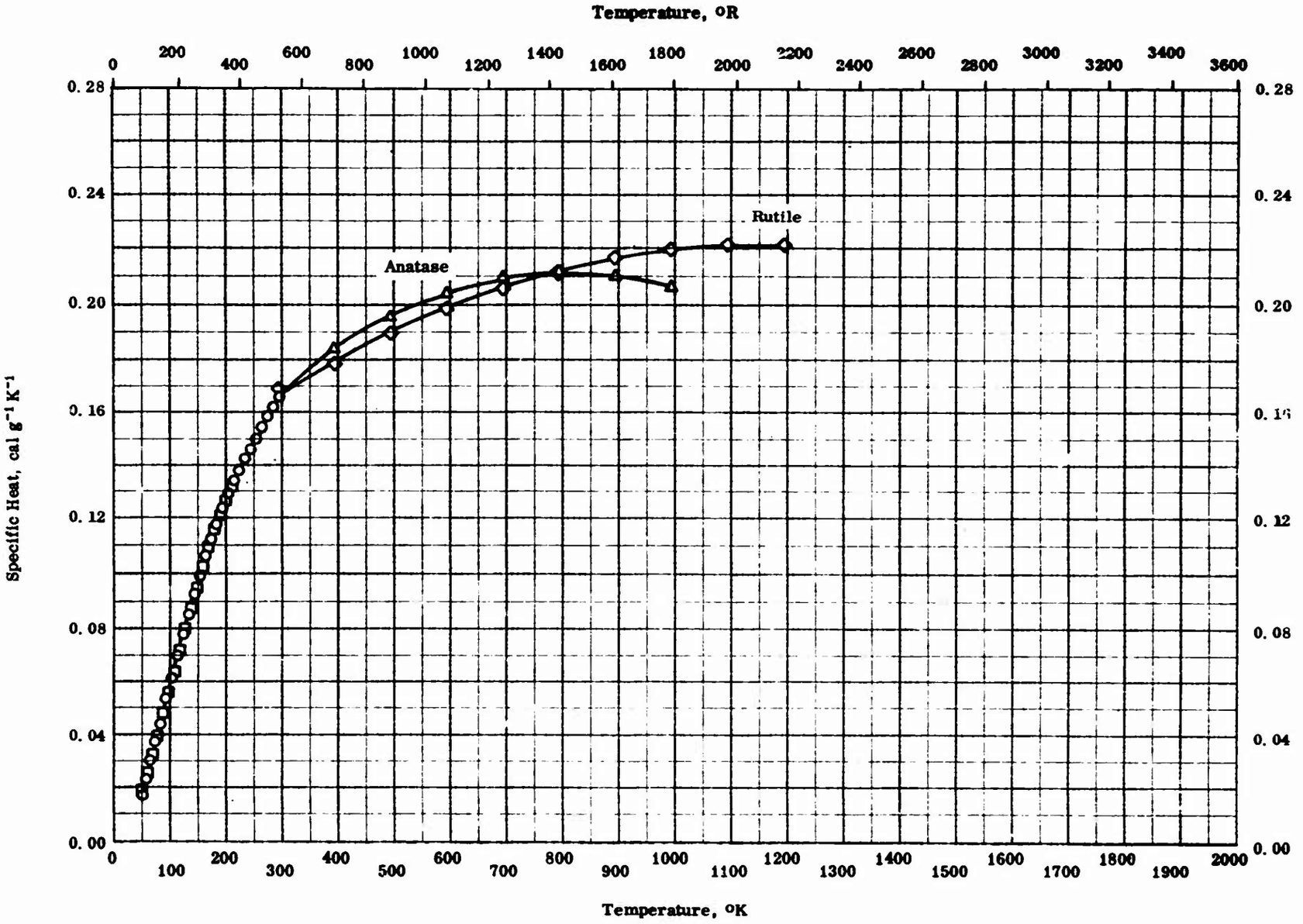


SPECIFIC HEAT -- TITANIUM MONOXIDE

SPECIFIC HEAT -- TITANIUM MONOXIDE

REFERENCE INFORMATION

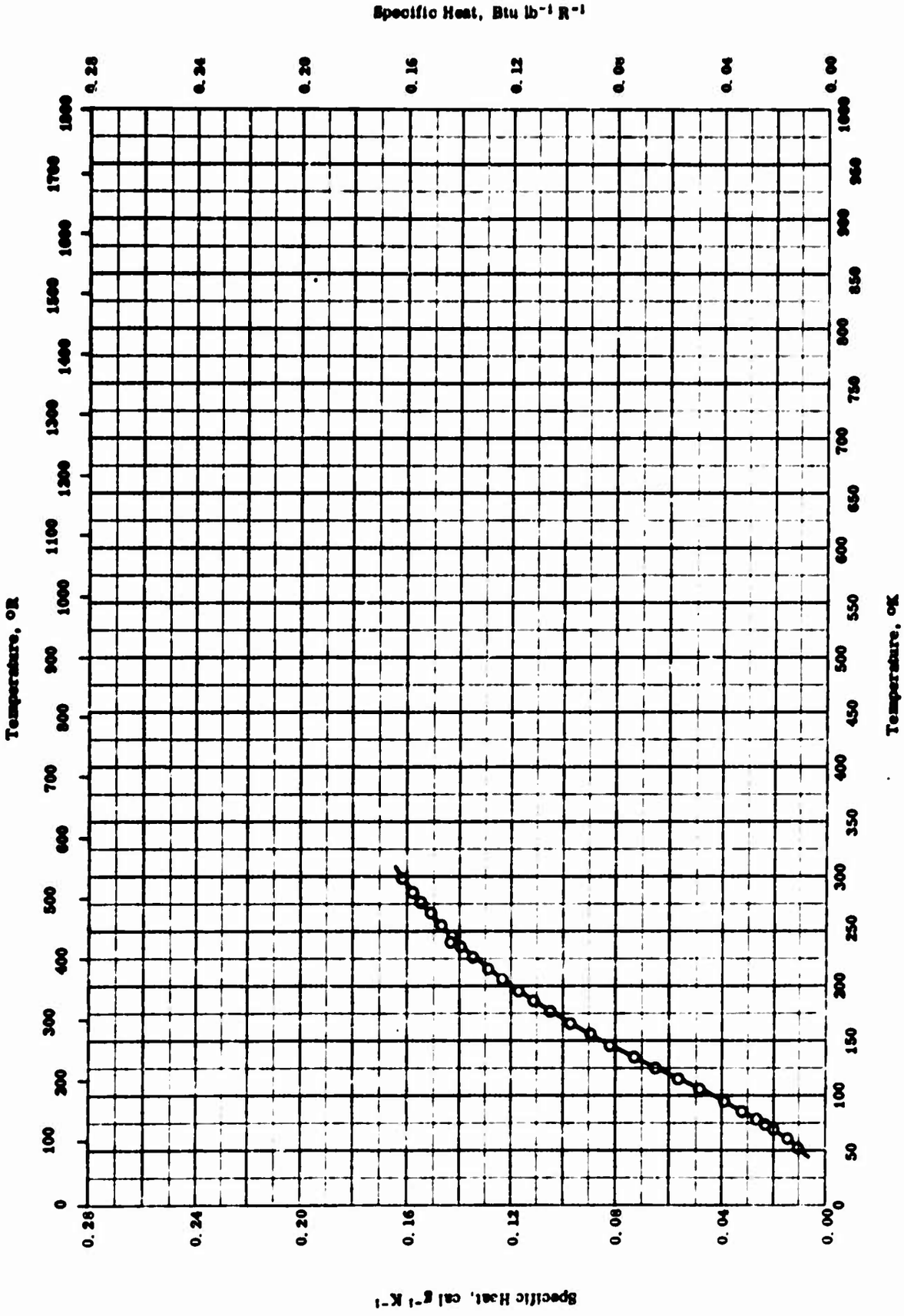
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	46-1	52-298		99.2 TiO, 0.7 Si, and 0.1 Ti.	



SPECIFIC HEAT -- TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	47-5	52-298	±0.3	99.3 TiO_2 and 0.3 H_2O; density 242 lb ft^{-3}; anatase.	Corrected for H_2O.
□	47-5	52-298	±0.3	99.7 TiO_2; density 265 lb ft^{-3}; rutile.	Same as above.
△	56-8	393-993		Density 243.7 lb ft^{-3}; anatase.	Synthetically prepared from doubly distilled $TiCl_4$; heated 4 hrs at 565 C.
◇	56-8	293-1193		Density 259.1 lb ft^{-3}; rutile; white with slight yellow cast.	Same as above except heated 1.5 hrs at 930 C.

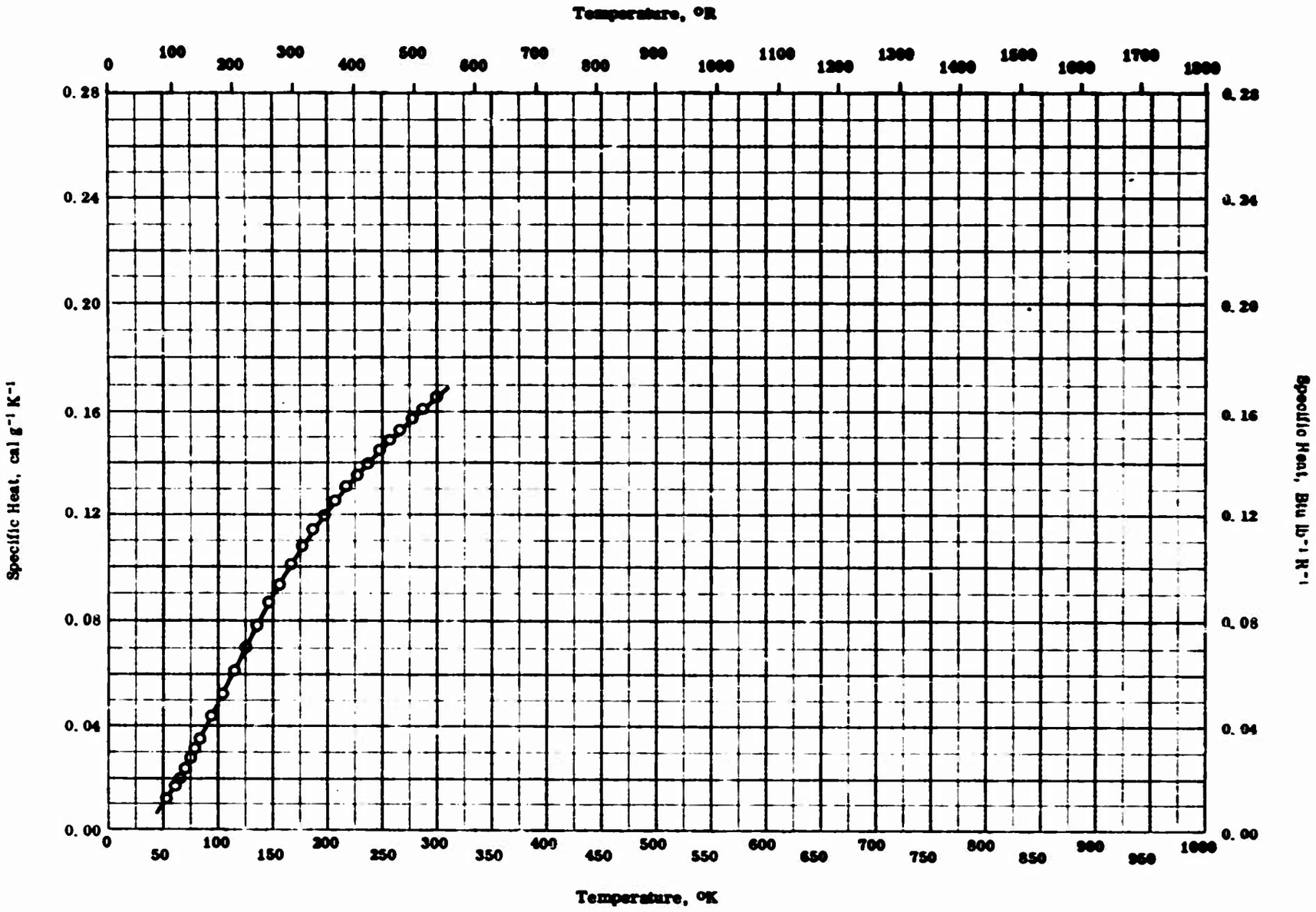


SPECIFIC HEAT -- TITANIUM SESQUIOXIDE

SPECIFIC HEAT -- TITANIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	46-1	53-298		99.4 Ti_2O_3, 0.3 TiC, and 0.3 SiO_2.	



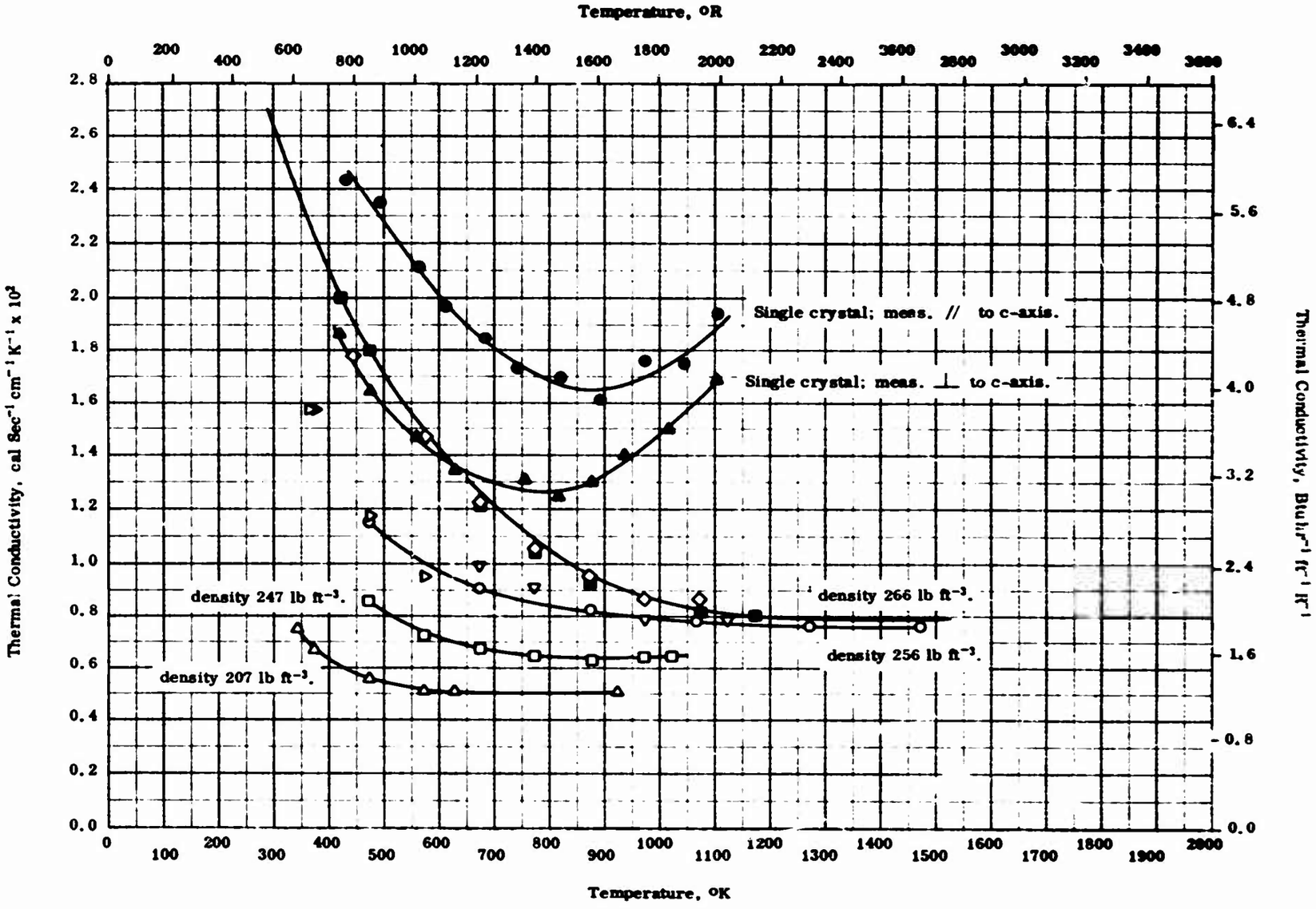
TPKC

SPECIFIC HEAT -- TRITITANIUM PENTOXIDE

SPECIFIC HEAT -- TRITITANIUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	46-1	53-298		99.1 Ti_3O_5, 0.7 SiO_2 and 0.2 TiC.	

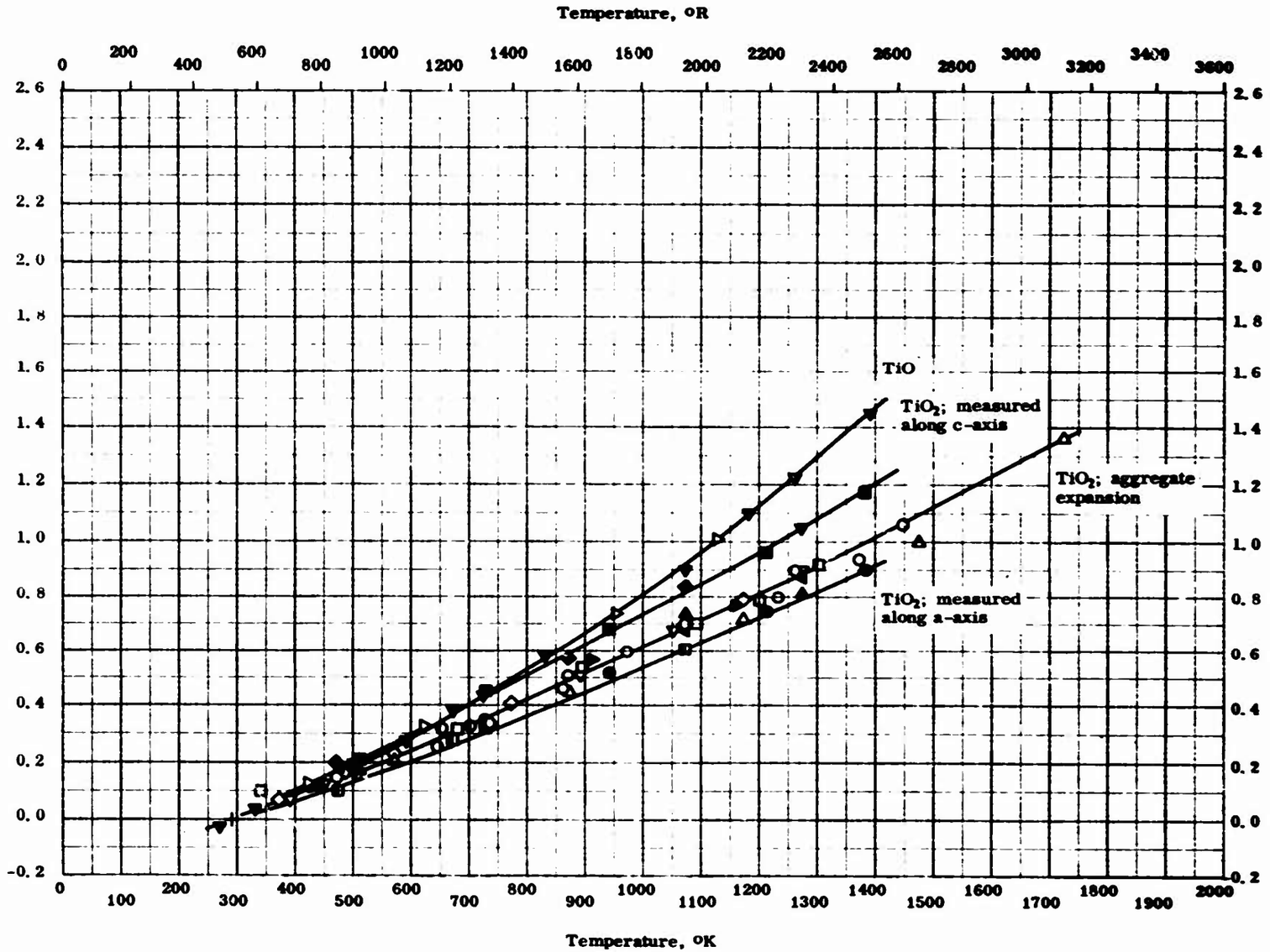


THERMAL CONDUCTIVITY -- TITANIUM DIOXIDE

TPRC

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-1	473-1473		Chemically pure TiO_2; density 257 lb ft^{-3} (cf. theor. density 266) porosity 3.5%.	Calcined at 1000 C, acid leached, slip cast, and fired at 1700 C in oxidizing atmos.
□	55-5	473-1023		Dense TiO_2; made from 100% heavy grade TiO_2; binder consists of 500 g carbowax, 10 g methocel and 7% water; density 247 lb ft^{-3}; apparent porosity 0.1%.	Pressed at 4400 psi and fired 20 min. at 1390 C.
△	55-5	343-923		Porous TiO_2; made from 70% titanox calcined 1 hr. at 1500 C and 30% RA-10-MC; binder consisted of 500 g carbowax, 10 g methocel and 7% water; density 207 lb ft^{-3}; porosity 17.1%.	Fired for 1 hr. at 1390 C.
◇	55-2	373-1073		TiO_2; average crystal size 15 microns; porosity 2.1%.	Sintered 2 hr. at 1250 C.
▽	55-2	673-1123		TiO_2; average crystal size 28 microns; porosity 3.0%.	Sintered 8 hr. at 1450 C.
■	57-4	423-1173		Polycrystalline TiO_2; average crystal size 15 microns; porosity 2.1%.	Data corrected to zero porosity.
▷	60-2	365-570		Rutile.	
●	55-3	432-1105		TiO_2; single crystal.	Measured parallel to c-axis.
▲	55-3	419-1102		TiO_2; single crystal.	Measured normal to c-axis.



THERMAL LINEAR EXPANSION -- TITANIUM OXIDES

TPRC

THERMAL LINEAR EXPANSION -- TITANIUM OXIDES

REFERENCE INFORMATION

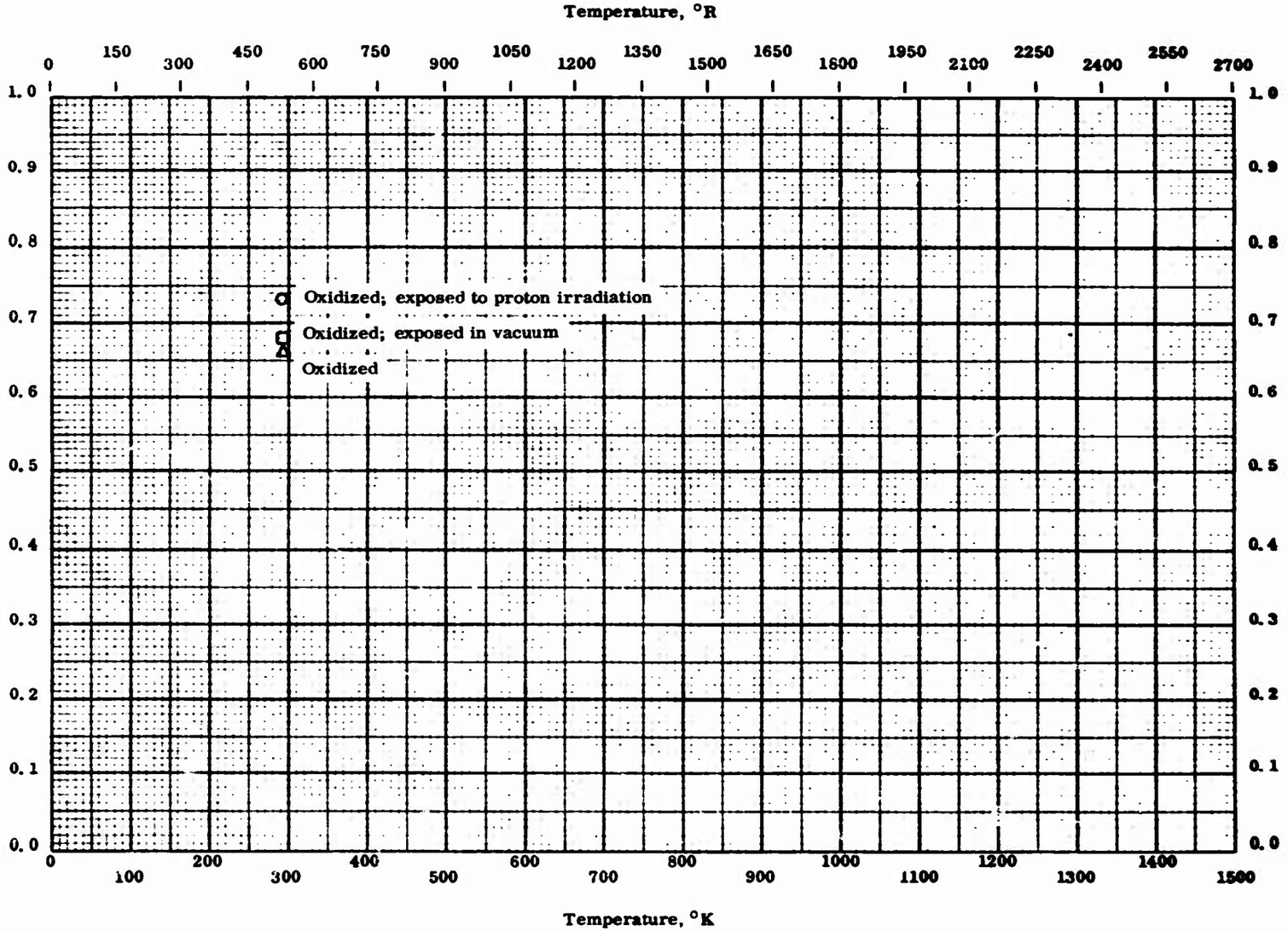
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
●	62-28	299-1383	2-3	99.9 TiO_2 (rutile), 0.001 - 0.01 Fe, and trace of Mg and Si; tetragonal.	Mixture of approx. 60 TiO_2 and 40 Pt powder ground together, fired at 1200 C for 6 hrs, cooled, and reground; Pt powder used for furnace alinement and thermal calibration; measured along a-axis with x-ray diffractometer.
■	62-28	299-1383	2-3	Same as above.	Same as above except measured along c-axis.
▲	60-36	297-1273	2	TiO_2; Titanox TG from Titanium Pigment Corp.; 0.01> CaO, 0.1> WO_3, 0.008> Nb, 0.007> Sb_2O_3, 0.04> SiO_2, 0.006 Fe_2O_3, 0.001 V, 0.00005 Mn, 0.0005 Cu, 0.0004 Cr, and 0.001 - 0.002 Pb.	Ball milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15 binder (40 g Carbowax 20 M, 20 cc of 2 Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired, cooled to room temperature in less than 30 min, and crushed to -325 mesh; measured along a-axis by x-ray diffraction.
▼	60-36	297-1273	2	Same as above.	Same as above except measured along c-axis.
◧	63-37	298-1273		TiO_2.	Measured along a-axis with x-ray diffractometer.
◆	63-37	298-1273		TiO_2.	Measured along c-axis with x-ray diffractometer.
○	56-31	273-1448		TiO_2.	Air atm.
◀	63-37	298-1273		TiO_2; dimensions approx 1 by 1 by 10 cm.	Fired at 1200 C for 6 hrs; aggregate expansion.

(Continued onto next page)

THERMAL LINEAR EXPANSION -- TITANIUM OXIDES (continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	56-31	273-1306		TiO_2.	Fired at 1700 C in oxidizing atm, ground to 325 mesh, and presintered at 1200 C in air; tested in He atm; averaged expansion along a and c axes, measured by x-ray diffraction, to represent polycrystalline solid.
△	56-28	573-1723		Coarse fused grain TiO_2.	
◇	47-6	293-1173		C. P. grade TiO_2.	Heated 12 hrs at 1100 C and matured 6 hrs at 1250 - 1430 C.
◐	55-37	273-703		$TiO_{1.97}$; oxygen deficient rutile or "Black Rutile".	Prepared by heating TiO_2 to 1538 C in vacuum; x-ray diffraction method.
▽	51-25	293-1273		100 TiO_2.	Fired 2 hrs at 1540 C and 8 hrs at 1500 C.
▼	56-31	273-1391		TiO.	Measured in vacuum.
▷	56-31	423-1391		Same as above.	Cooling cycle for above sample.
▶	56-31	273-1163		TiO.	Measured in He atm by x-ray method; above 600 C x-ray patterns were poor; after heating sample above 600 C, room temperature patterns also were poor.

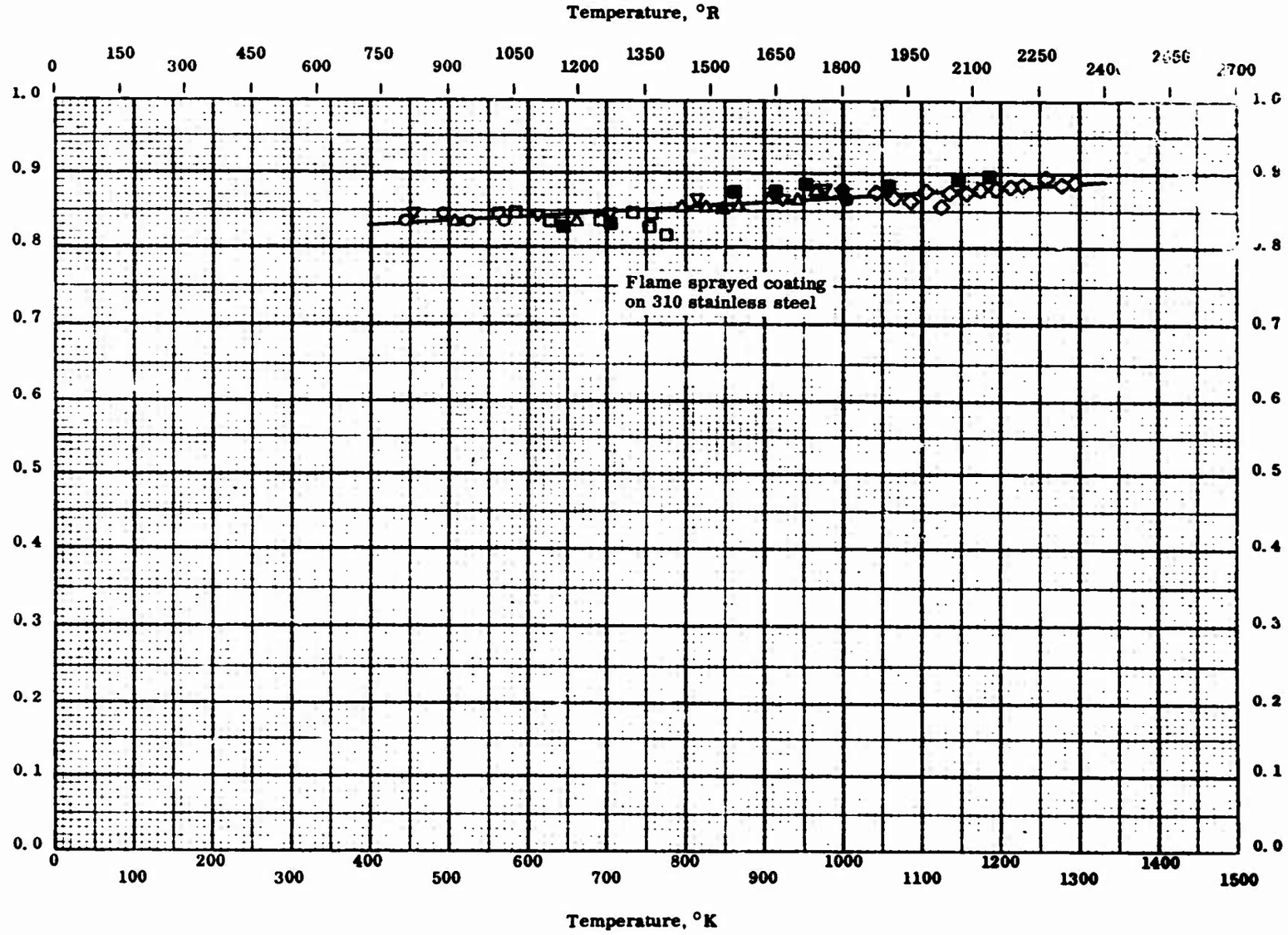


SOLAR ABSORPTANCE -- TITANIUM DIOXIDE

SOLAR ABSORPTANCE -- TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	60-27	298		TiO_x, vacuum deposited titanium film, 0.8 - 1.0 μ thickness on aluminum foil.	Oxidized at 673 K for 3 hrs; exposed to 700 Mev proton irradiation, 1.5×10^{13} protons cm^{-2}; above atmosphere.
□	60-27	298		Same as above.	Oxidized at 673 K for 3 hrs; exposed in vacuum (10^{-6} mm Hg) for 6 days, cleaned with isopropyl alcohol; above atmosphere.
△	60-27	298		Same as above.	Oxidized at 673 K for 3 hrs.

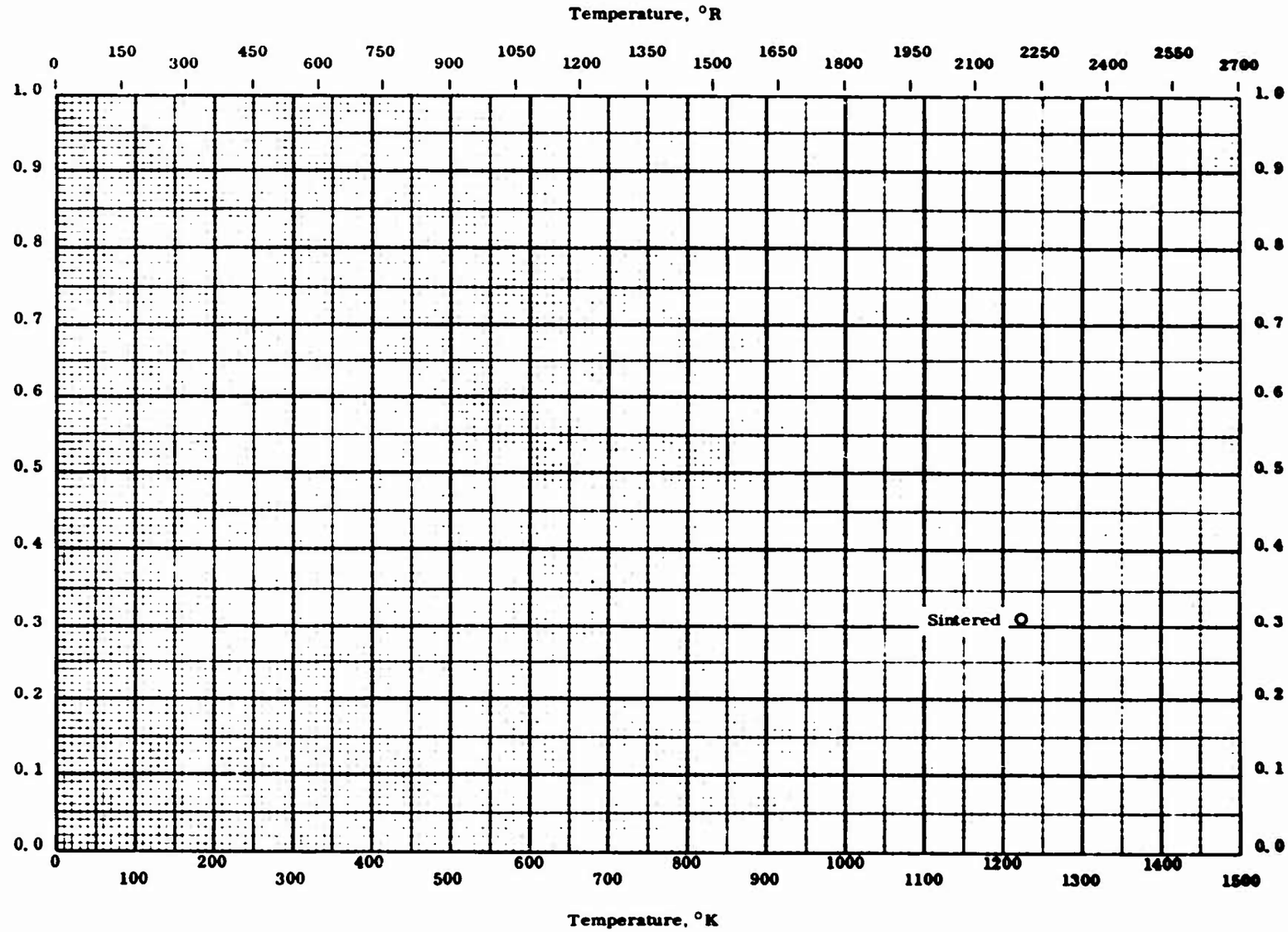


HEMISPHERICAL TOTAL EMITTANCE -- TITANIUM DIOXIDE

HEMISPHERICAL TOTAL EMITTANCE -- TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	60-31	445-570		TiO_2, flame-sprayed coating 0.0025 in. thickness on type 310 stainless steel.	Measured in vacuum; run no. 1A.
□	60-31	563-779		Same as above.	Same as above; run no. 1B.
△	60-31	509-966		Same as above.	Same as above; run no. 2A.
●	60-31	1000-1004		Same as above.	Same as above; run no. 2B.
▽	60-31	454-1007		Same as above.	Same as above; run no. 3.
◇	60-31	999-1292		Same as above.	Same as above; run no. 4A.
■	60-31	649-1261		Same as above.	Same as above; run no. 4B.



TPRC

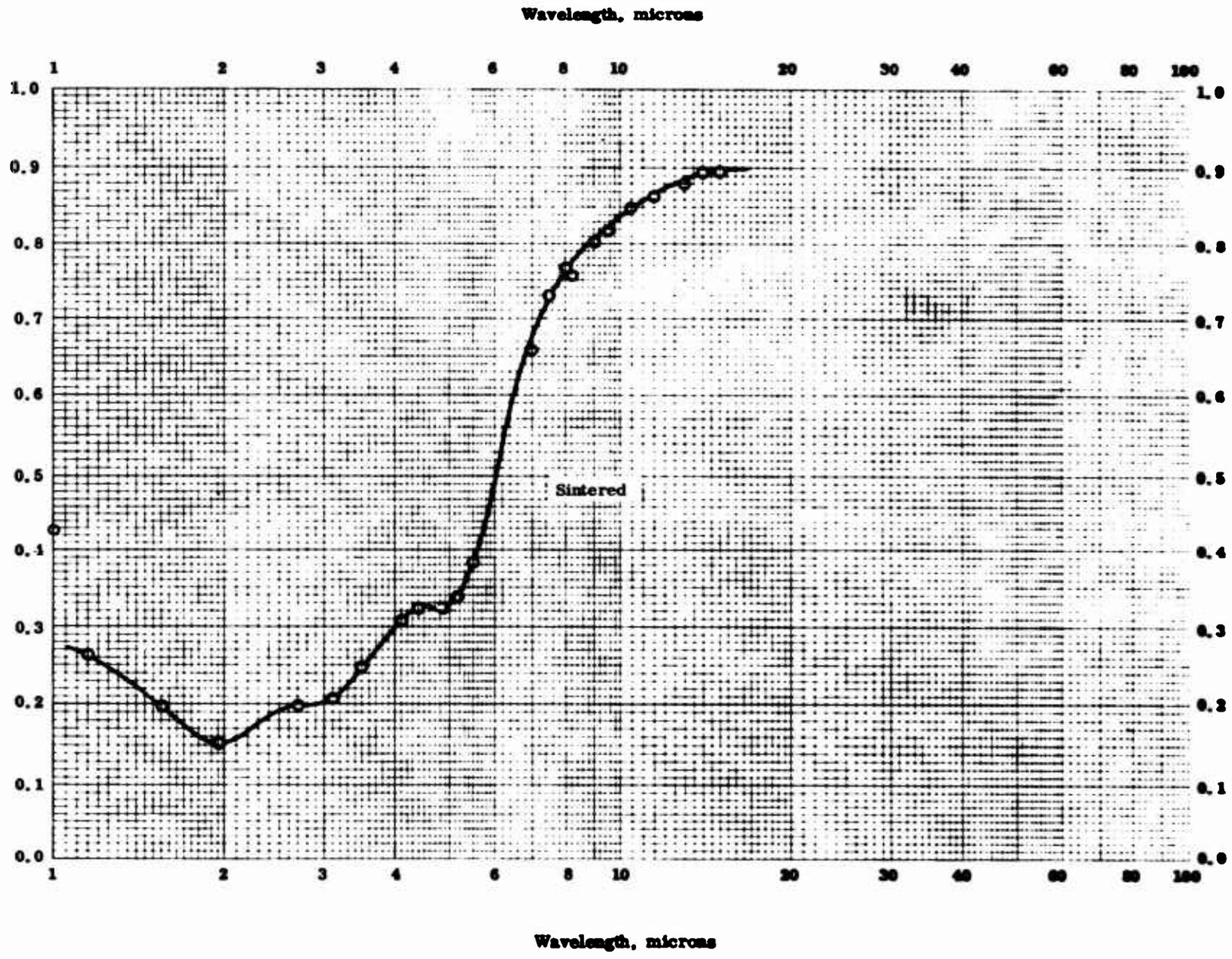
NORMAL TOTAL EMITTANCE -- TITANIUM DIOXIDE

NORMAL TOTAL EMITTANCE -- TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-26	1223	±8	TiO_2, 0.069 in. thickness plate.	Sintered at 1673 K for 2 hrs; measured in argon atmosphere; computed from spectral data.

TPRC



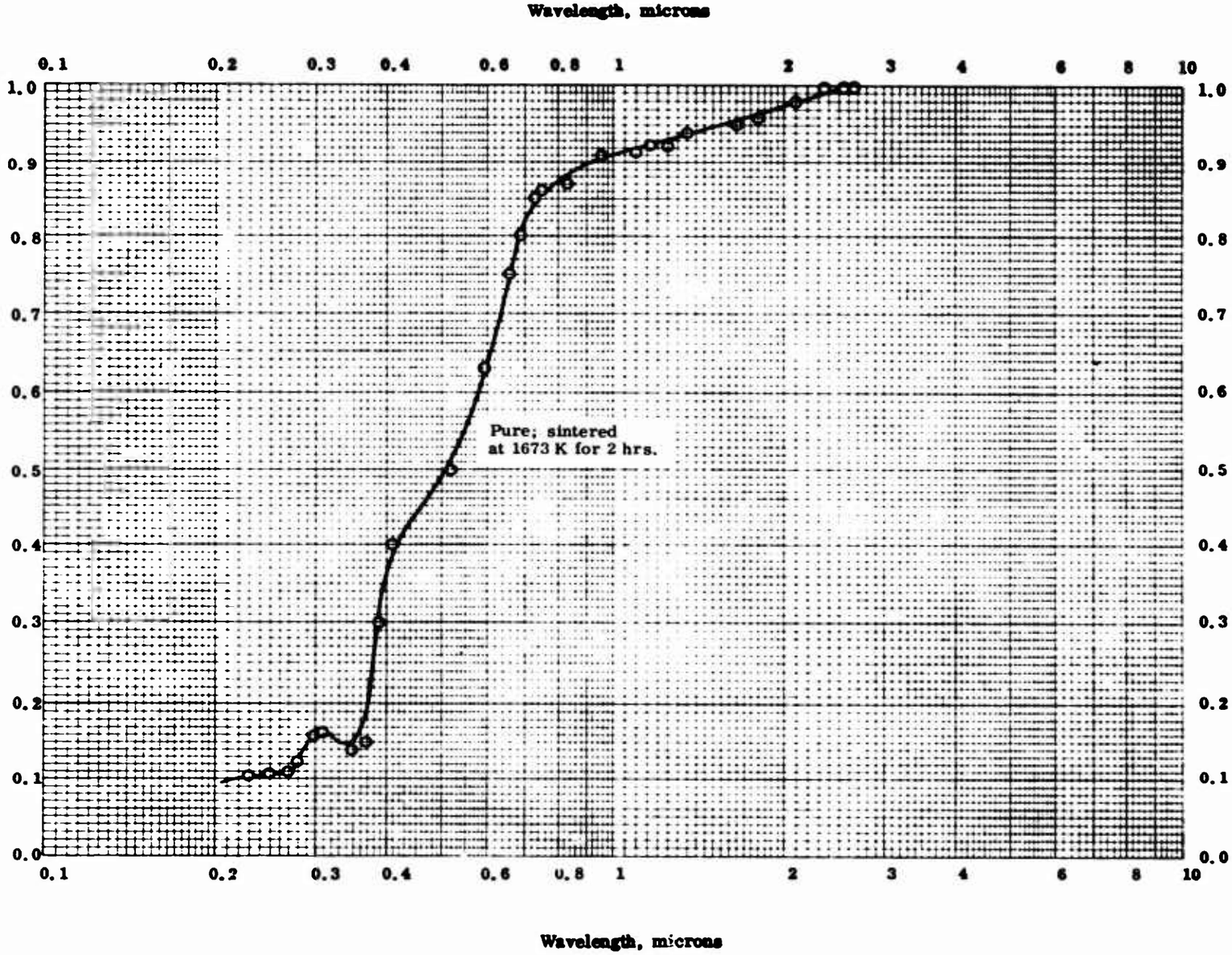
NORMAL SPECTRAL EMITTANCE -- TITANIUM DIOXIDE

NORMAL SPECTRAL EMITTANCE -- TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
O	63-26	1223	1-15		TiO_2, 0.069 in. thickness plate; density 3.87 g cm^{-3}.	Sintered at 1673 K for 2 hrs; measured in argon atmosphere; data taken from a curve.

TPRC

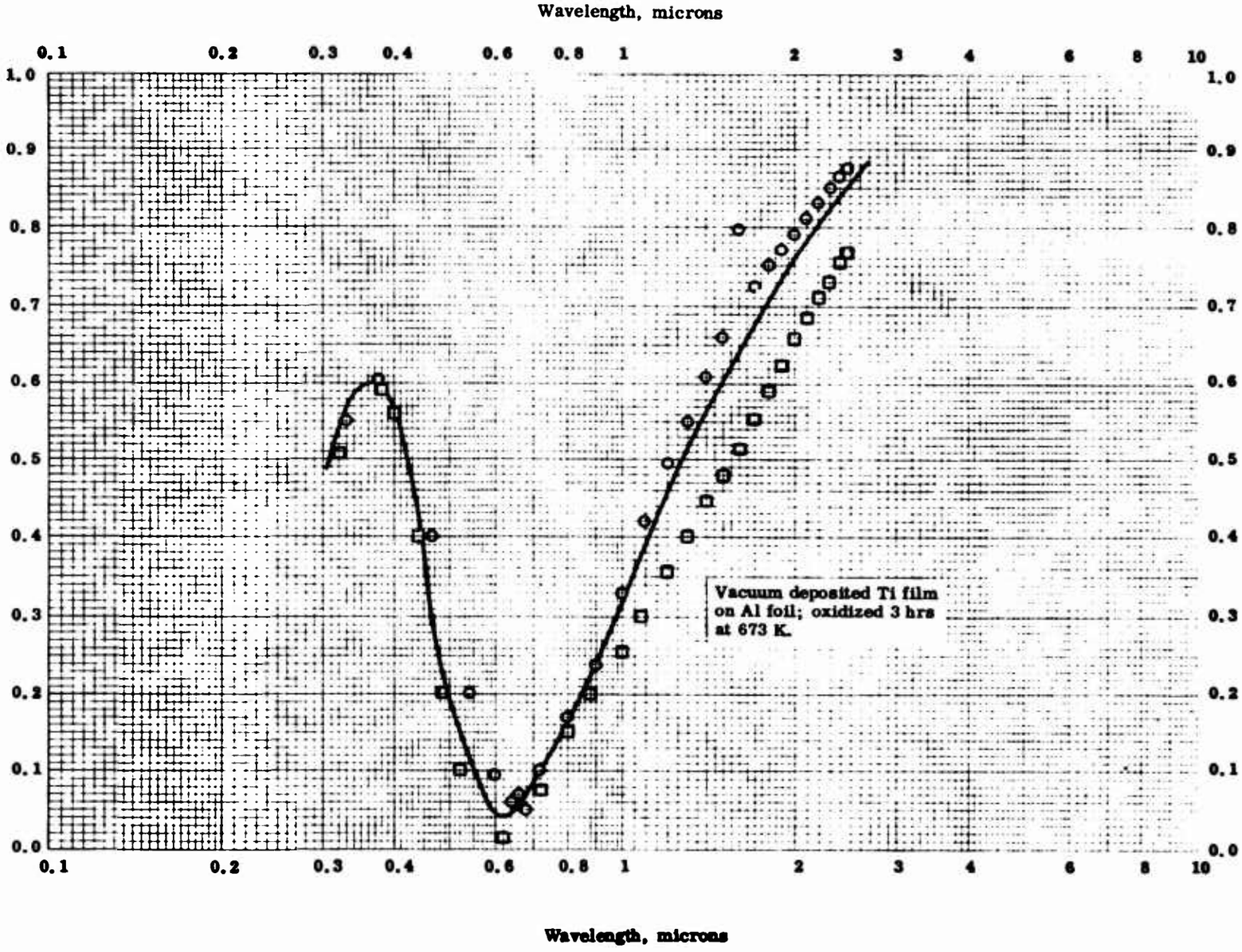


NORMAL SPECTRAL REFLECTANCE -- TITANIUM DIOXIDE

NORMAL SPECTRAL REFLECTANCE -- TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
O	63-26	298	0.23-2.65	5	TiO_2, pure, 0.069 in. thickness; density 3.87 g cm^{-3}.	Sintered at 1673 K for 2 hrs; data taken from a curve; MgO as reference standard; normal illumination, hemispherical viewing.

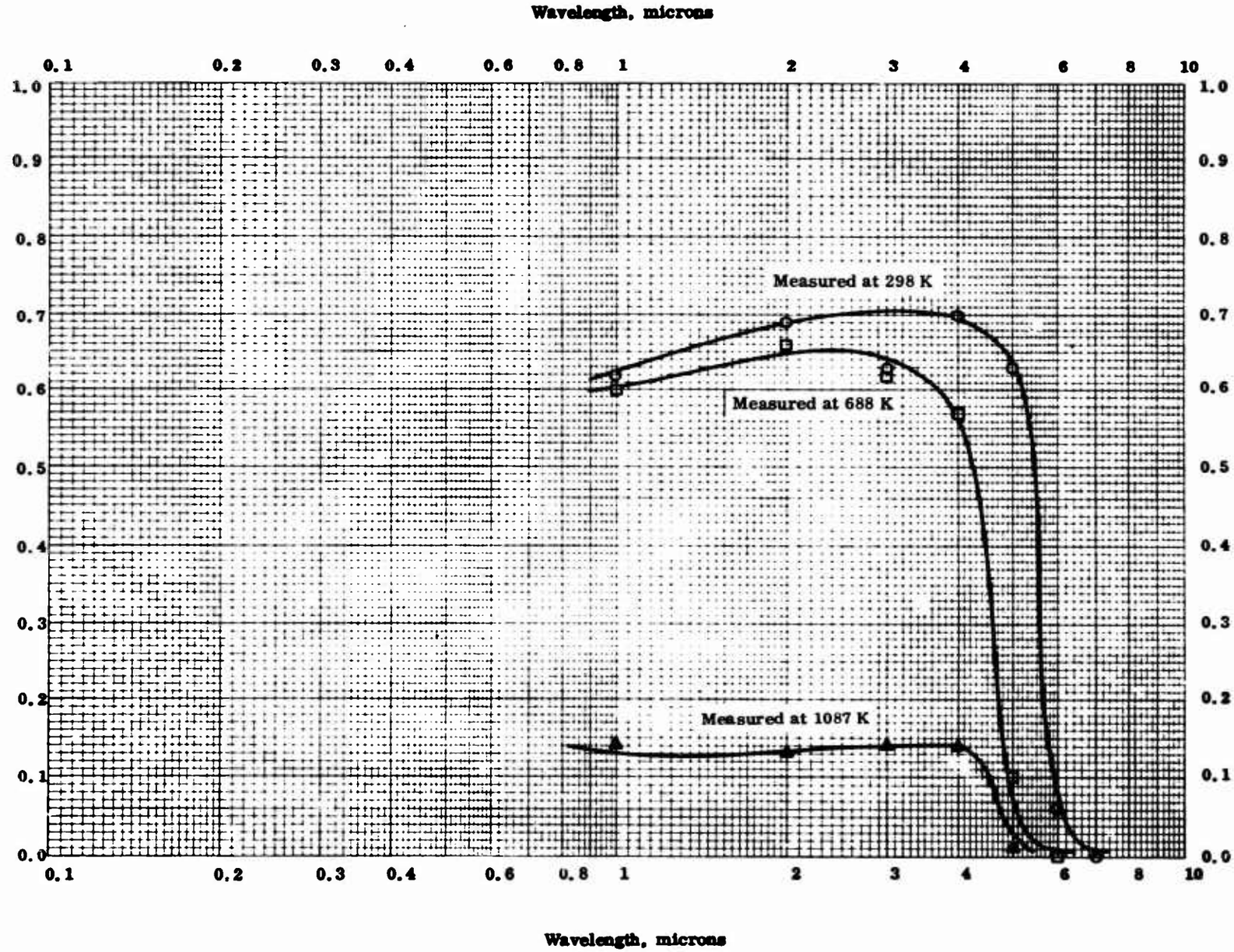


ANGULAR SPECTRAL REFLECTANCE -- TITANIUM DIOXIDE

ANGULAR SPECTRAL REFLECTANCE -- TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	60-27	298	0.33 - 2.47		TiOx, vacuum deposited titanium film; 0.8 - 1.0 μ thickness on Al foil.	Oxidized 3 hrs at 673 K; data taken from smooth curve; 15° incidence.
□	60-27	298	0.32 - 2.46		Same as above.	Oxidized 3 hrs at 673 K; exposed to 700 Mev proton irradiation, 1.9 x 10^{15} protons cm^{-2}; data taken from smooth curve; 15° incidence.

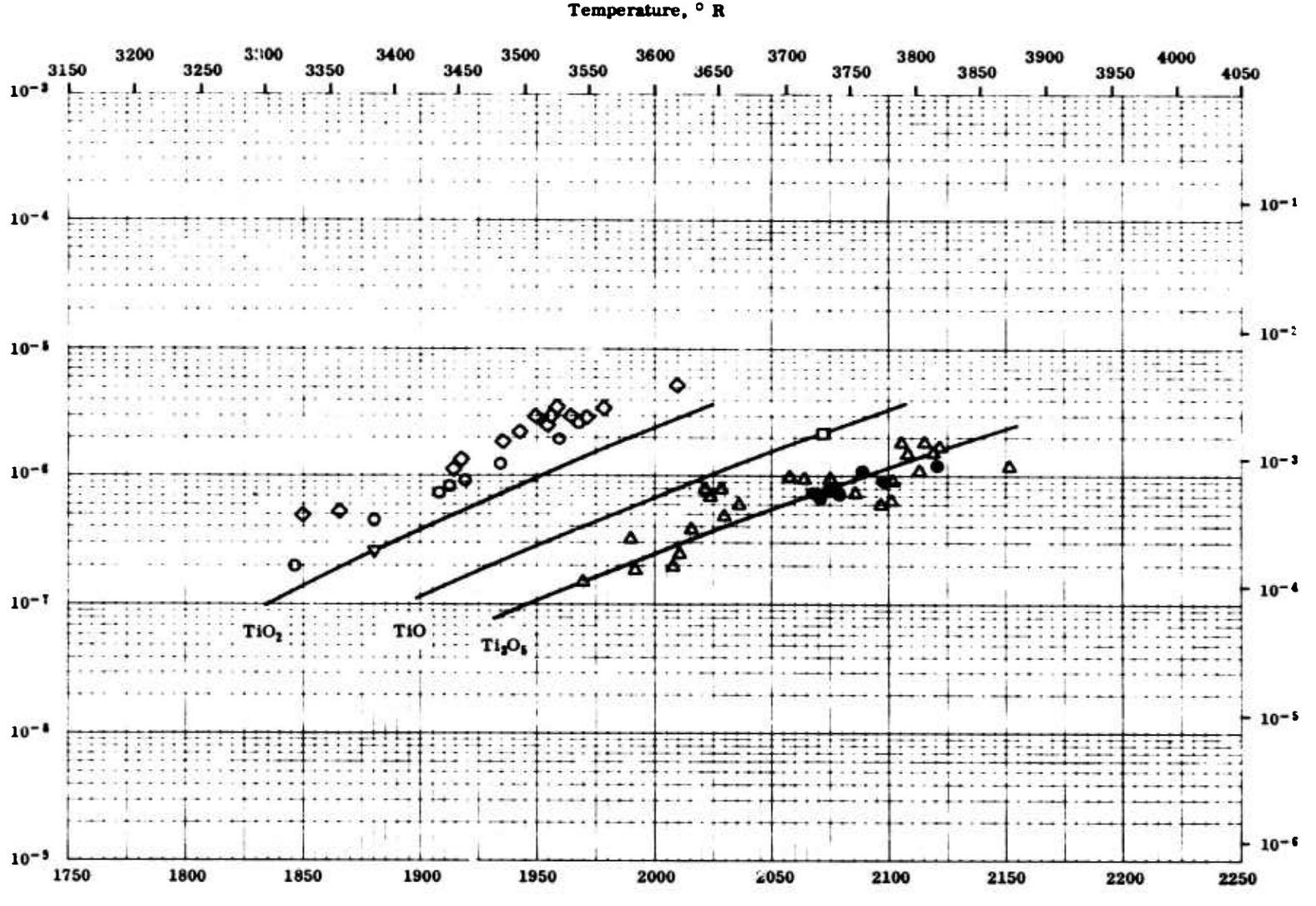


NORMAL SPECTRAL TRANSMITTANCE -- TITANIUM DIOXIDE

NORMAL SPECTRAL TRANSMITTANCE -- TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
○	64-12	298	1-7	±5	TiO_2, Linde single crystal.	
□	64-12	688	1-7	±5	Same as above.	
△	64-12	1087	1-7	±5	Same as above.	



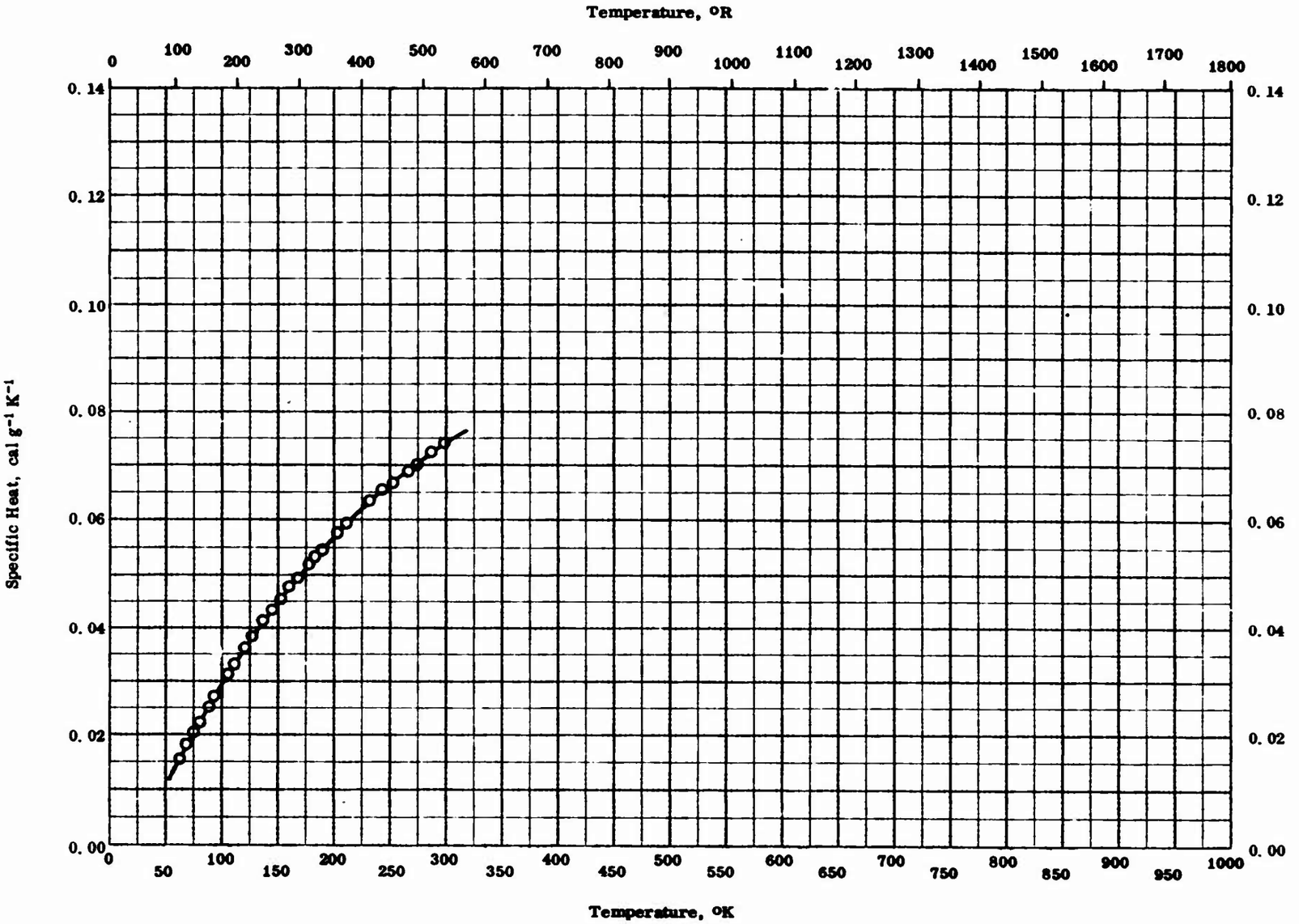
TPRC

VAPOR PRESSURE -- TITANIUM OXIDES

VAPOR PRESSURE -- TITANIUM OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	55-13	1847-1968		TiO; actually $TiO_{1.075}$ for two points and $TiO_{1.029}$ for others; from "Baker's Analysed" c.p. TiO_2 and iodide process Ti.	Ta cell, degassed, corrected for weight loss; additional oxygen in solid to inhibit $TiO(s) \rightarrow TiO_2(s) + Ti(g)$.
△	55-13	1971-2151		Ti_2O_3; raw materials same as above.	Mo lined Ta cell, degassed, corrected for weight loss; $Ti_2O_3(s) \rightarrow TiO(g) + TiO_2(g)$; author stated that the assumption: $p_{TiO} = p_{TiO_2}$ introduces error of only 0.47%; therefore report results as $\sqrt{p_{TiO} \cdot p_{TiO_2}}$.
◇	55-13	1849-2010		TiO_2; actually $TiO_{1.9}$; raw materials same as above.	Mo lined Ta cell, degassed, corrected for weight loss; $TiO_{1.9}$ used to inhibit effusion of O_2; for detailed explanation see pp. 129 of article.
●	55-13	2068-2122		Ti_3O_5; raw materials same as above.	Data treated as $Ti_3O_5(s) \rightarrow Ti_2O_3(s) + TiO_2(g)$; results reported as p_{TiO_2}.
□	57-10 also 56-3	2072		TiO.	Mo lined Ta cell and Thoria cell; author stated $p_{Ti} \simeq p_{TiO}$ in spite of small amount of additional oxygen.
▽	57-10 also 56-3	1881		TiO_2.	Mo lined Ta cell and Thoria cell; results with first cell affected by evolution of large amounts of Mo oxides.

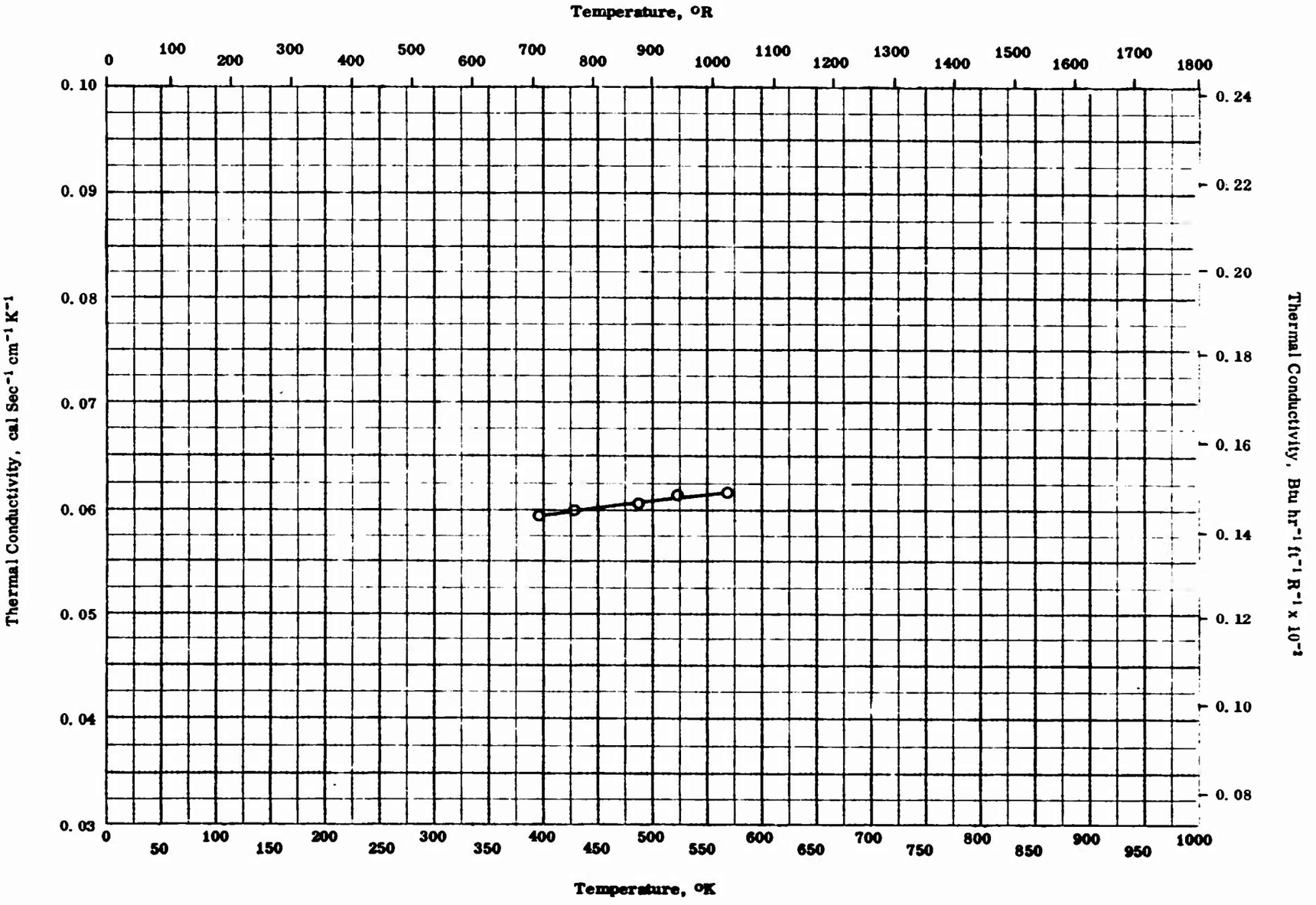


SPECIFIC HEAT -- TUNGSTEN TRIOXIDE

SPECIFIC HEAT -- TUNGSTEN TRIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	43-5	63-299	± 0.3	WO_3; rhombohedral crystal.	



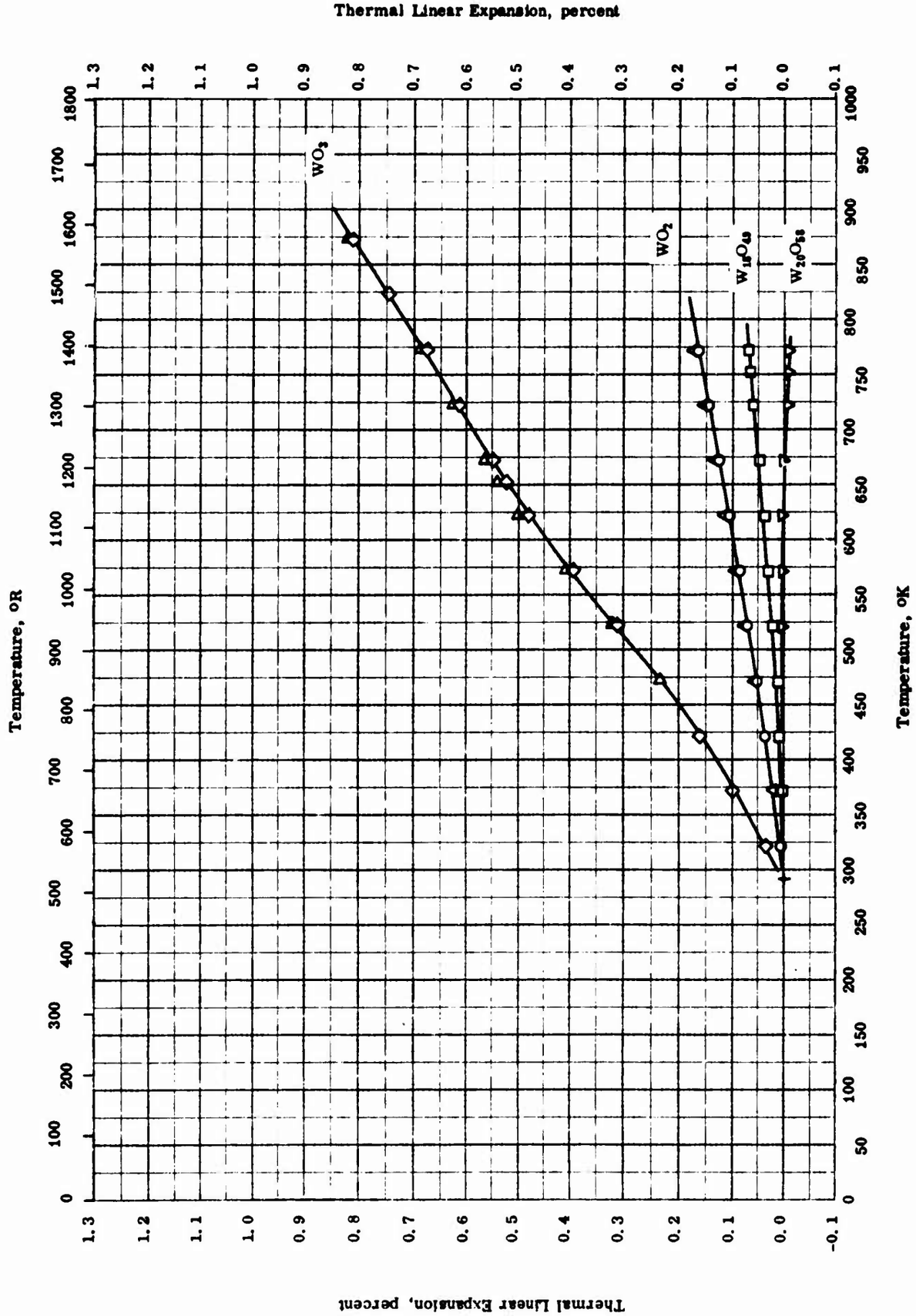
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THERMAL CONDUCTIVITY -- TUNGSTEN TRIOXIDE

THERMAL CONDUCTIVITY -- TUNGSTEN TRIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	55-10	396-568		0.28 ZnO; coarse crystalline structure; considerable porosity.	Prepared by firing H_2WO_3 and ZnO.



THERMAL LINEAR EXPANSION -- TUNGSTEN OXIDES

THERMAL LINEAR EXPANSION -- TUNGSTEN OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	64-29	303-773		95< WO_2; prepared from reagent grade WO_3 from Wako Pure Chemical Industries and metallic W powder from Tokyo Tungsten Co.; polycrystalline.	Stoichiometric amounts of WO_3 and W powder weighed into ratio $WO_{2.00}$, mixed, heated to 950 C for 40 hrs in nitrogen, crushed, dry-pressed into pellets 55 mm long and 5 by 5 mm in cross section, and sintered for 15 min with heating and cooling rate of 10 C min^{-1}; measurements made with heating rate of 2.5 - 3 C min^{-1} in air; author states precision ±10 ppm in length measurements.
△	64-29	303-773		Same as above.	Second run for above sample.
□	64-29	303-773		95< $W_{18}O_{49}$; raw materials same as above; polycrystalline.	Same as above except WO_3 and W powder weighed into ratio $WO_{2.72}$, mixed, and heated to 1000 C for 40 hrs in nitrogen.
▽	64-29	303-773		95< $W_{20}O_{58}$; raw materials same as above; polycrystalline.	Same as above except WO_3 and W powder weighed into ratio $WO_{2.90}$, mixed, and heated to 1050 C for 80 hrs in nitrogen.
◇	64-29	303-873		95< WO_3; prepared from reagent grade WO_3, from Wako Pure Chemical Industries, mixed with water; polycrystalline. [Author's design : Sample A]	Dry-pressed at 2500 kg cm^{-2}, sintered at 900 C in air with heating rate of 2 C min^{-1} near 900 C, and ground to 50 mm long by 3 - 4 mm in diameter rod; measured with heating rate of 2.5 - 3 C min^{-1} in air; author states precision of ±10 ppm in length measurements.

(Continued onto next page)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▷	64-29	303-873		Same as above. [Author's design : Sample B]	Same as above except sintered at 1100 C.

PROPERTIES OF URANIUM OXIDES

REPORTED VALUES

Density		g cm^{-3}	lb ft^{-3}
○	U_2O_5.	8.35	521
□	U_3O_8.	8.42	526
△	U_3O_8.	8.34	521
◇	UO_3.	1.94	121
▽	UO_3.	3.60	225
◁	UO_3.	1.58	98.6
▷	UO_2 and 0.2 Al_2O_3.	8.337	520.5
●	UO_2 and 0.5 Al_2O_3.	8.260	515.7
■	UO_2 and 1.0 Al_2O_3.	7.449	465.0
▲	UO_2 and 2.0 Al_2O_3.	7.120	444.5
▼	UO_2 and 0.1 MnO_2.	7.975	497.9
◀	UO_2 and 0.2 MnO_2.	7.613	475.3
▶	UO_2 and 0.5 MnO_2.	7.953	496.5
◆	UO_2 and 1.0 MnO_2.	7.942	495.8
◐	UO_2 and 0.2 TiO_2.	8.458	528.0
◧	UO_2 and 0.3 TiO_2.	8.414	525.3
◭	UO_2 and 0.1 TiO_2.	8.030	501.3
◬	UO_2 and 0.2 TiO_2.	8.546	533.5
◮	UO_2 and 0.5 TiO_2.	8.403	524.6
◈	UO_2.	10.25	639.9
◑	UO_2.	10.60*	661.7*
◨	UO_2.	10.37	647.4
◭	UO_2.	10.95	683.6
◬	UO_2.	10.90	680.5
◮	UO_2.	10.02 ± 0.1	625.5 ± 6
▶	UO_2.	11.11 ± 0.2	693.6 ± 13
◈	UO_2 and 0.1 CaF_2.	8.611	537.6
◓	UO_2 and 0.2 CaF_2.	8.469	528.7
◒	UO_2 and 0.5 CaFe.	8.315	519.1
◙	UO_2 and 1.0 CaF_2.	8.107	506.1
◍	UO_2 and 2.0 CaF_2.	7.449	465.0
◍	UO_2 and 0.1 ZrH_2.	7.712	481.4
◔	UO_2 and 0.2 ZrH_2.	7.997	499.2
◔	UO_2 and 0.5 ZrH_2.	7.569	472.5
◪	UO_2 and 1.0 ZrH_2.	6.801	424.6

*Most probable value for this compound.

PROPERTIES OF URANIUM OXIDES (continued)

REPORTED VALUES

Melting Point		K	R
▶	UO_2	3153 ±20	5676 ± 36
■	$UO_{1.98}$	3033 ±30	5460 ± 54
◪	UO_2	3153*	5675*
■	UO_2	3003 ±30	5406 ± 54
◆	UO_3	925	1665
◆	U_3O_8	1950	3510

*Most probable value for this compound.

PROPERTIES OF URANIUM OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	48-4	298		U_2O_5.	Density from x-ray measurement of lattice.
□	48-5	298		U_3O_8.	Same as above.
△	48-5	298		U_3O_8.	Density by pycnometer.
◇	56-26	298		UO_3.	Type II.
▽	56-26	298		UO_3.	Type III.
◁	56-26	298		UO_3.	Type III; made by very slow denitration of uranyl nitrate hexahydrate (UNH).
▷	56-26	298		UO_2 and 0.2 Al_2O_3.	Normal MCW UO_2 powder mixed with metal oxide; pressed at 126,000 psi and fired 2 hrs at 1400 C in steam.
●	56-26	298		UO_2 and 0.5 Al_2O_3.	Same as above.
■	56-26	298		UO_2 and 1.0 Al_2O_3.	Same as above.
▲	56-26	298		UO_2 and 2.0 Al_2O_3.	Same as above.
▼	56-26	298		UO_2 and 0.1 MnO_2.	Same as above.
◀	56-26	298		UO_2 and 0.2 MnO_2.	Same as above.
▶	56-26	298		UO_2 and 0.5 MnO_2.	Same as above.
◆	56-26	298		UO_2 and 1.0 MnO_2.	Same as above.
◐	56-26	298		UO_2 and 0.2 ThO_2.	Same as above.
◧	56-26	298		UO_2 and 0.3 ThO_2. (continued onto next page)	Same as above.

REFERENCE INFORMATION

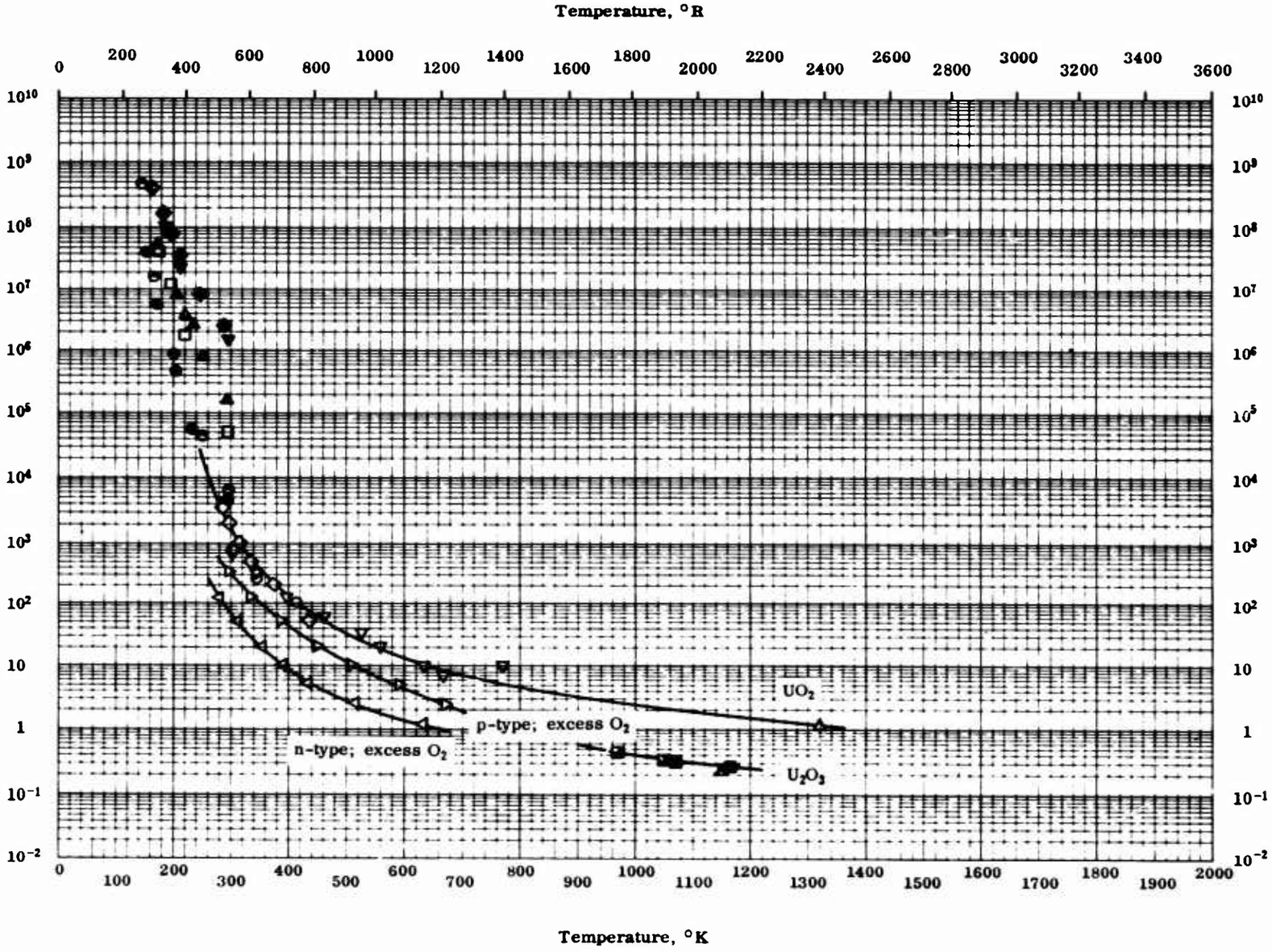
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▲	56-26	298		UO_2 and 0.1 ZrO_2.	Same as above.
▼	56-26	298		UO_2 and 0.2 ZrO_2.	Same as above.
◀	56-26	298		UO_2 and 0.5 ZrO_2.	Same as above.
◆	52-15, 54-30, also 56-20	298		Typical analysis before fabrication; 0.083 MgO, 0.002 Al_2O_3, 0.001 each CuO, Fe_2O_3, and SiO_2; supplied by Mallinckrodt as -325 mesh.	Pressed at 70,000 psi and fired at 1750 C in H_2 atm.
▶	52-15, 54-30, also 56-20	3133-3173		Same as above.	Same as above; M. P. inspected as powder sample with grain size below 74 μ after heating it in tungsten crucible in He atm.
●	54-30 also 56-20	298		Same as above.	Same as above except first pebble-milled 56 hrs.
■	54-30 also 56-20	298		Same as above.	Same as above except first calcined at 1750 C and then pebble-milled 16 hrs.
▲	54-30 also 56-20	298		Same as above.	Same as above except pebble-milled 140 hrs without first being calcined.
▼	56-20	298		Same as above. (continued onto next page)	Pressed at 800 psi and fired at 1750 C in H_2

PROPERTIES OF URANIUM OXIDES (Continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◀	56-20	298		Pure UO_2 by Norton Co.	Electrically fused.
▶	53-28	298		UO_2.	
■	57-33	3003-3063		$UO_{1.98}$ by Mallinckrodt.	M. P. by visual observation and observation of break in time-temperature curve.
◆	56-26	298		99.9 UO_2 and 0.1 CaF.	Normal MCW UO_2 powder mixed with metal fluoride, pressed at 126,000 psi, and fired 2 hrs at 1400 C in stream.
●	56-26	298		99.8 UO_2 and 0.2 CaF.	Same as above.
●	56-26	298		99.5 UO_2 and 0.5 CaF.	Same as above.
■	56-26	298		99.0 UO_2 and 1.0 CaF.	Same as above.
●	56-26	298		98.0 UO_2 and 2.0 CaF.	Same as above.
●	56-26	298		99.9 UO_2 and 0.1 ZrH_2.	Same as above except UO_2 mixed with ZrH_2.
●	56-26	298		99.8 UO_2 and 0.2 ZrH_2.	Same as above.
●	56-26	298		99.5 UO_2 and 0.5 ZrH_2.	Same as above.
■	56-26	298		99.0 UO_2 and 1.0 ZrH_2.	Same as above.
■	64-9	3153		UO_2.	
⊠	63-24	2973-3033		UO_2.	Measured in He.
◆	45-4	925		UO_3.	Decomposition to U_3O_8 in 1 atm. O_2.
◆	45-4	1950		U_3O_8.	

TPRC

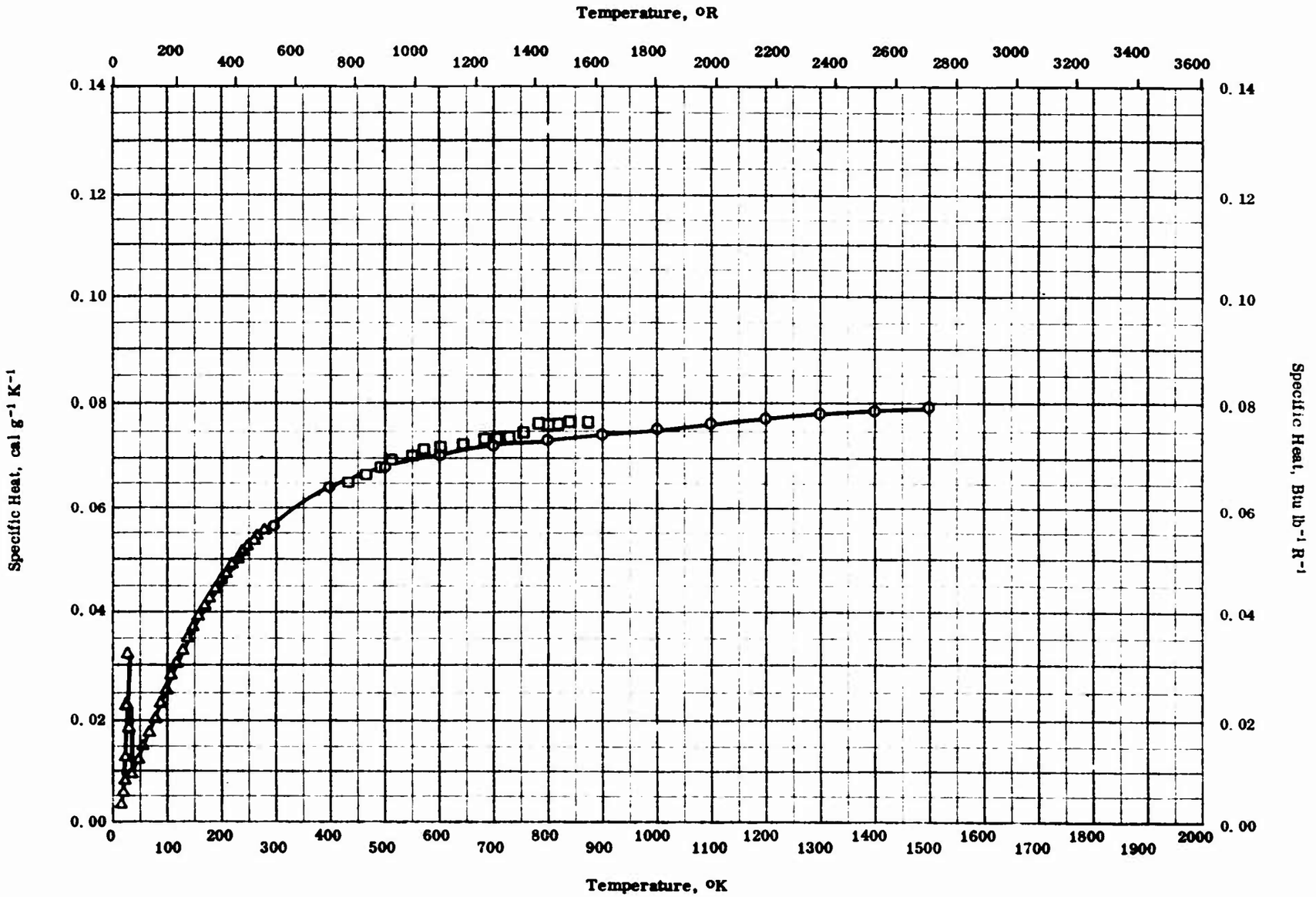


ELECTRICAL RESISTIVITY -- URANIUM OXIDES

ELECTRICAL RESISTIVITY -- URANIUM OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-24	303-417		UO_2; mixed from elements with 0.01> transition and rare earth metals.	Pressed, fired 8 hrs at 1750 C in H_2.
△	41-3	1320		UO_2.	Sintered at 1600-1800 C.
◇	56-17	286-438		UO_2; 0.0003> metallic impurities; n-type; density 86% theoretical.	Pressed from Mallingkrodt UO_2 powder at 100,000 psi (no binder) and sintered 1 hr at 2050 C; corrected to zero porosity.
▽	56-17	301-956		Same as above; density 79-95% theoretical.	Same as above, except sintered 1 hr at 1600 C; two samples.
▷	56-17	297-689		Three samples ranging $UO_{2.032}$ - 2.160; p-type; density 60% theoretical.	Mallingkrodt UO_2 powder oxidized, pressed at 100,000 psi (without binder), not sintered, annealed at 400 C, and quenched.
◁	56-17	280-675		Three samples ranging $UO_{2.206}$ - 2.353; n-type;	Same as above.
◪	41-3	968-1163		U_2O_3.	At 1 atm. O_2.
●	63-21	156-298		UO_2; single crystal.	
□	63-21	178-298		Same as above.	Irradiated with neutron flux 1.2×10^{15} nvt-cm^{-2}.
▲	63-21	173-298		Same as above.	Irradiated with neutron flux 3.4×10^{15} nvt-cm^{-2}.
◆	63-21	141-298		Same as above.	Another sample.
▼	63-21	167-288		Same as above.	Irradiated with neutron flux 6.7×10^{16} nvt-cm^{-2}.
⊖	63-21	178-298		Same as above.	Irradiated with neutron flux 8.8×10^{16} nvt-cm^{-2}.



SPECIFIC HEAT -- URANIUM DIOXIDE

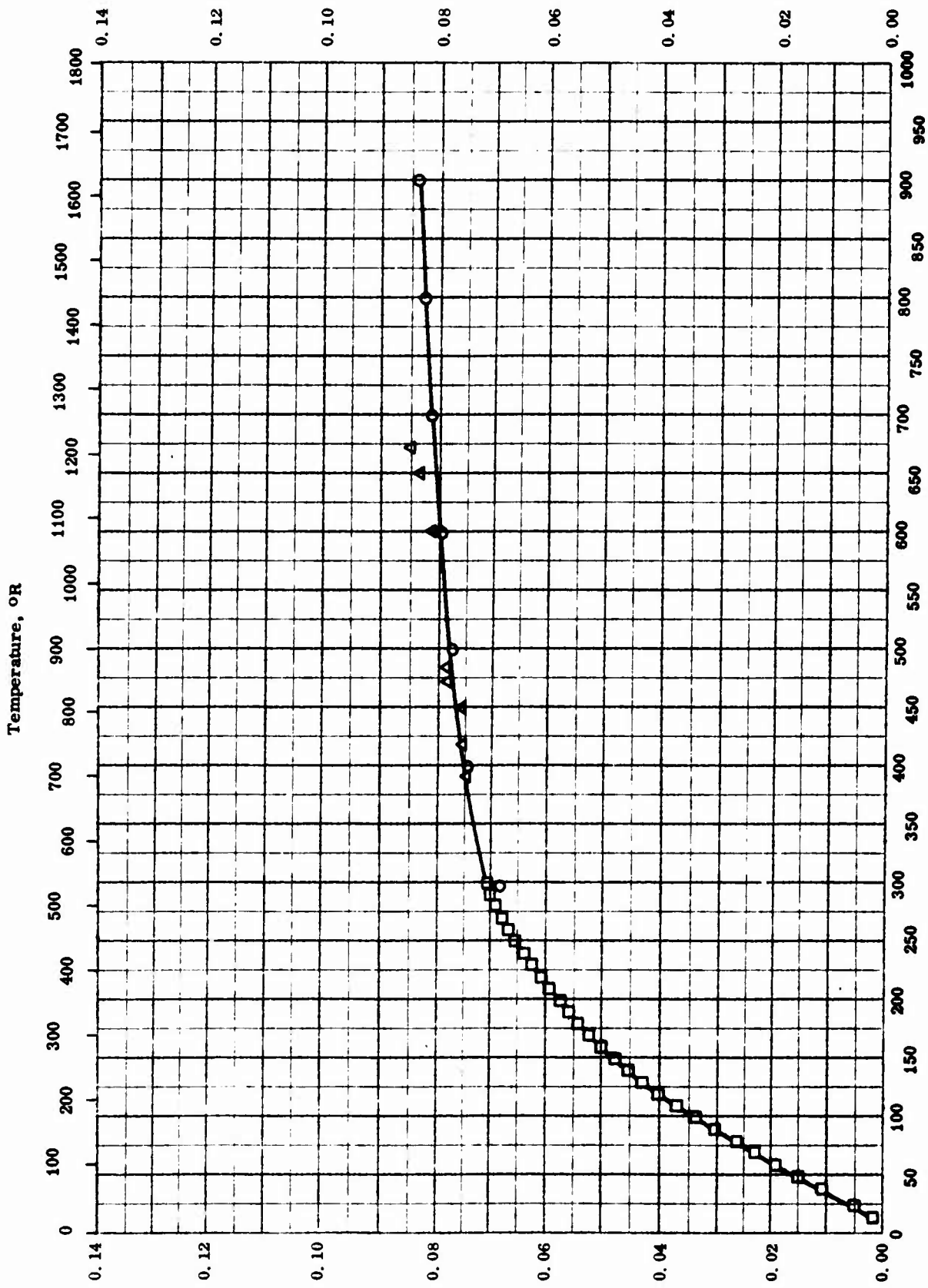
SPECIFIC HEAT -- URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	47-3 also 42-2	298-1500	0.1	UO_2 with 88.26 U.	
□	58-10	433-876	0.8	UO_2; 88.00 U and 0.01> Fe, Si.	Prepared by reduction of U_3O_8 with hydrogen at 800 C.
△	42-1 also 52-9	13-255	0.2	99.3 UO_2 with 88.26 U and traces other oxides; powder of well crystallized particles.	

TPRC

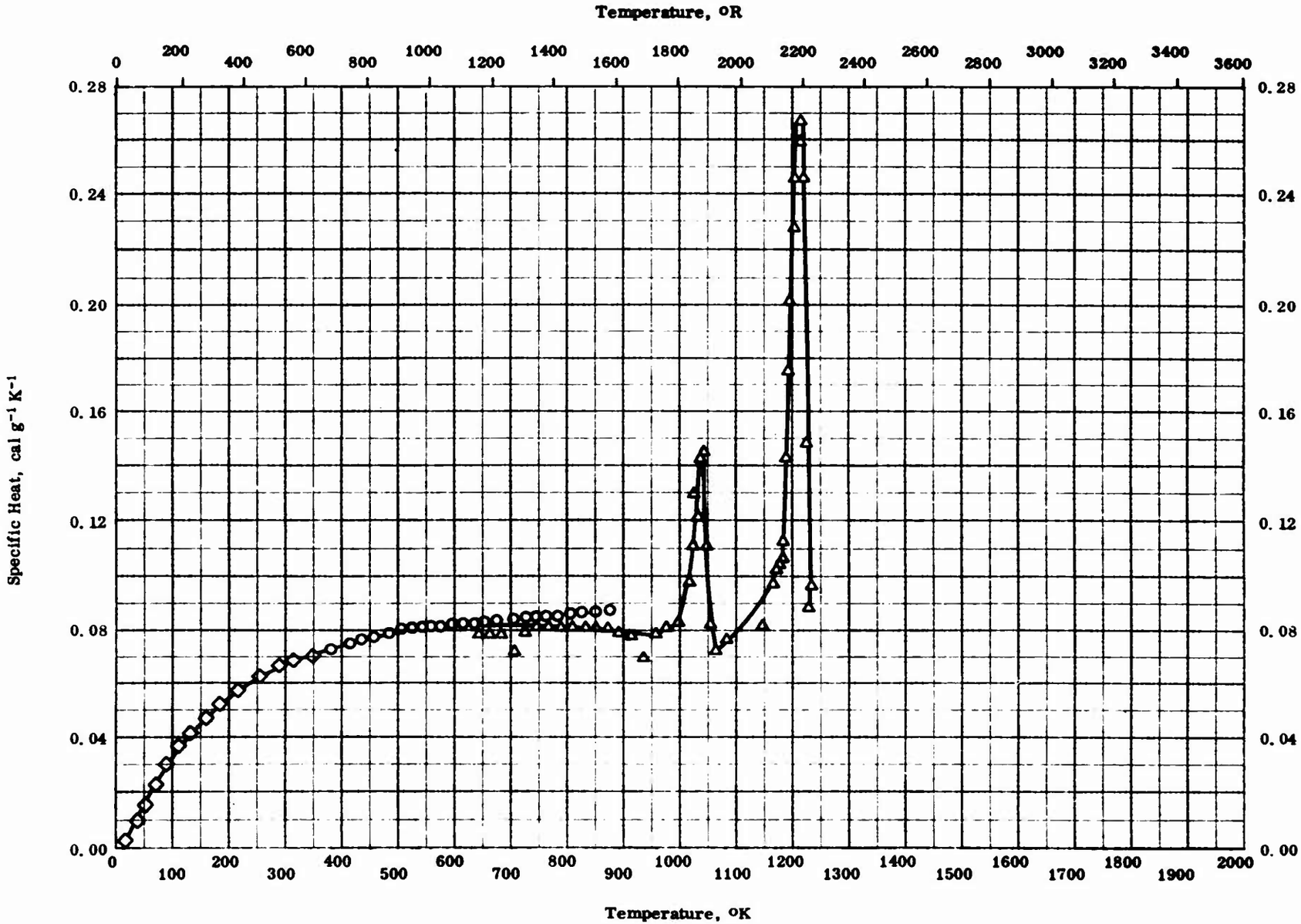
SPECIFIC HEAT -- URANIUM TRIOXIDE



SPECIFIC HEAT -- URANIUM TRIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	47-3 also 42-2	298-900	0.10	UO_3 with 83.02 U.	
□	42-1 also 52-9	13-294	0.2	UO_3 with 0.003 H_2O.	Prepared by decomposing uranyl nitrate 8 hrs at 300 C and ground dried 3 hrs at 100 C.
△	58-10	392-673	≤1.3	UO_3 with 83.00 U and 0.003 > Fe; amorphous orange powder.	Prepared by ignition of $UO_4 \cdot 2H_2O$ at 280-300 C.



SPECIFIC HEAT -- TRIURANIUM OCTOXIDE

SPECIFIC HEAT -- TRIURANIUM OCTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	58-10	380-875	0.6	U_3O_8; 84.79 U, 0.002 Fe, and 0.002 Si; deep olive green powder.	Prepared by ignition of $UO_2(NO_3)_2 \cdot 6H_2O$ at 850 C.
△	61-16	641-1233	1-3	U_3O_8 with 84.78 U.	
◇	59-17	5-347	0.1-1	U_3O_8; 0.020 Si, 0.006 Al, 0.003 Mg, 0.002 Ni, 0.001 Fe, 0.0003 Cu, 0.000008> B.	Prepared from uranyl nitrate hexahydrate. The U_3O_8 produced was reduced to UO_2 by heating in dry purified hydrogen gas at 500 C until H_2O formation ceased; temperature raised to 1200 C and sample kept at this temperature for 4 days before cooling to room temperature; oxidized in air at 800 C to constant weight and then heated 7 days at 800 C under vacuum; gradually cooled to room temperature over 2 months.

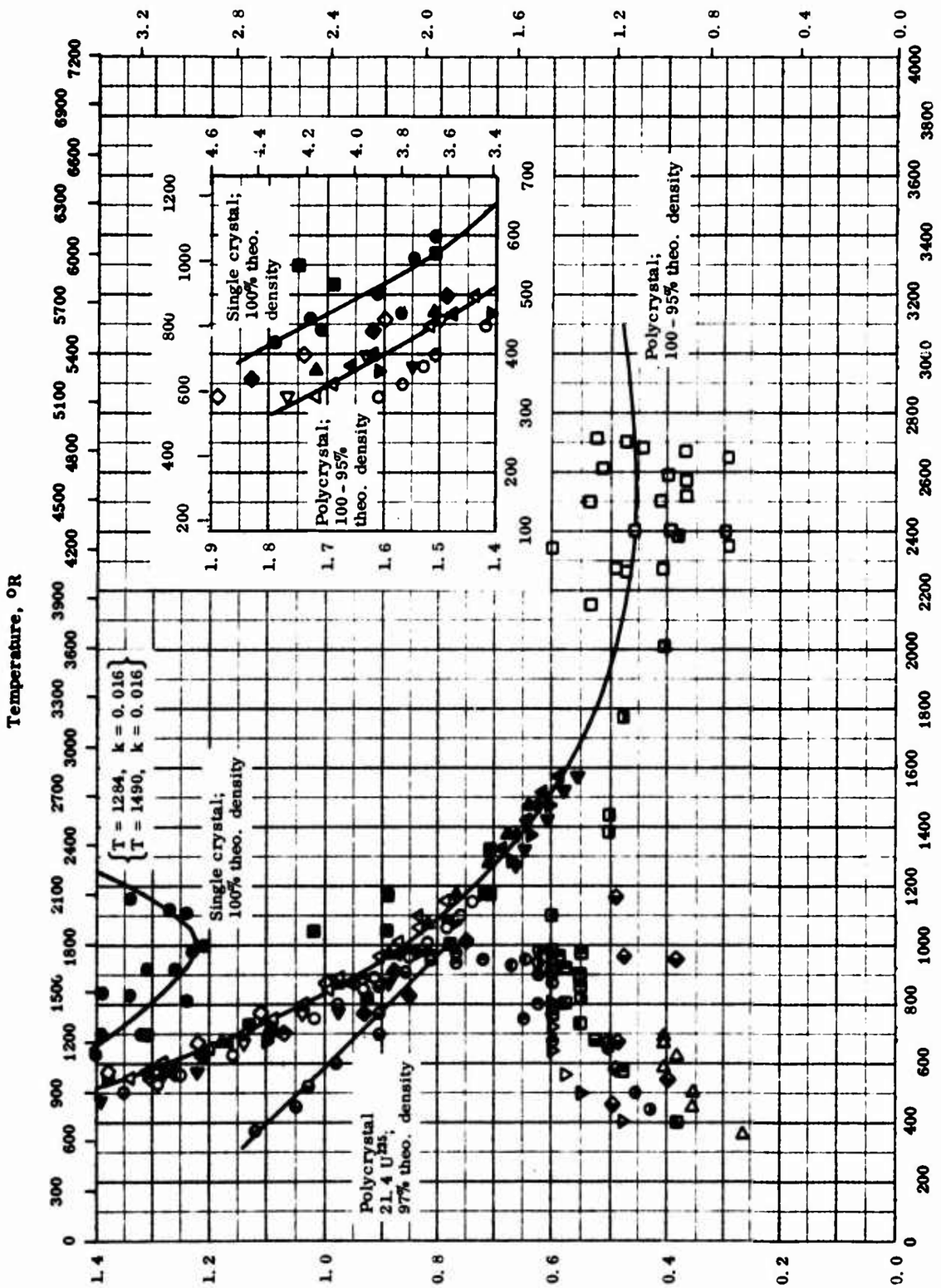
SPECIFIC HEAT -- TETRAURANIUM NONOXIDE

SPECIFIC HEAT -- TETRAURANIUM NONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error	Sample Specifications	Remarks
○	57-31	5-310	1.0	U_4O_9; 86.81 U, 13.14 O_2, 0.0070 Si, 0.0010 Al, 0.0010 Cu, 0.007 Fe, 0.0005 Mg, 0.0001 Pb and 0.00002 B.	Prepared by reducing U_3O_8 to UO_2 by heating in alumina boats in a stream of anhydrous hydrogen at 500 C until evolution of H_2O ceased; then heating for additional 4 hrs at 1200 C; cooled in H_2 atmosphere; stoichiometric UO_2 and U_3O_8 were mixed in quartz tubes and evacuated; mixture heated 7 days at 800 C and gradually cooled to 20 C over 2 months.
□	65-2	300-515		U_4O_9; prepared from 99.9 powdered UO_2.	Prepared by reduction of UO_2 in dry hydrogen gas 12 - 20 hrs; part of UO_2 was oxidized in air at 650 C for 5 hrs to U_3O_8; stoichiometric UO_2 and U_3O_8 were ground and mixed carefully to homogenous; heated at 950 C for 150 hrs and then gradually cooled to room temperature for 100 hrs.

TPRC



THERMAL CONDUCTIVITY -- URANIUM DIOXIDE

THERMAL CONDUCTIVITY -- URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◐	64-2	373-949		21.4 U^{235} ($51 \times 10^{+20}$ atoms cm^{-3}) in total U; thin walled (0.076 cm thick) fuel cylinder (0.907 cm O. D. and 12 cm long) with density 10.6 g cm^{-3} (97% of theoretical density). [Author's design.: BETT 69-4]	Pressure bonded between a nickel capsule and a thin inner tube supported by shrink-fitted alumina pellets from inside; total thermal exposure $0.00004 \times 10^{+20}$ - $0.014 \times 10^{+20}$ Nvt; measured in effective thermal conductance including thermal conductance between sample and nickel capsule.
◑	64-2	674-966		Same as above.	Same as above except total thermal exposure $0.04 \times 10^{+20}$ - $0.35 \times 10^{+20}$ Nvt.
◒	64-2	649-948		Same as above.	Same as above except total thermal exposure $0.39 \times 10^{+20}$ - $0.56 \times 10^{+20}$ Nvt and total burn-up $0.9 \times 10^{+20}$ fiss. cm^{-3}; values reported lower than actual.
◒	64-2	437-977		Same as above.	Same as above except total thermal exposure $0.57 \times 10^{+20}$ - $0.80 \times 10^{+20}$ Nvt and total burn-up $1.6 \times 10^{+20}$ fiss. cm^{-3}; values reported lower than actual.
◧	64-2	679-979		Same as above.	Same as above except total thermal exposure $0.85 \times 10^{+20}$ - $1.1 \times 10^{+20}$ Nvt and total burn-up $2.4 \times 10^{+20}$ fiss. cm^{-3}; values reported lower than actual.
◧	64-2	491-966		Same as above.	Same as above except total thermal exposure $1.2 \times 10^{+20}$ - $1.7 \times 10^{+20}$ Nvt and total burn-up $3.5 \times 10^{+20}$ fiss. cm^{-3}; values reported lower than actual.

(Continued onto next page)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
⊟	64-2	404-945		Same as above.	Same as above except total thermal exposure $1.7 \times 10^{+20}$ - $2.2 \times 10^{+20}$ Nvt and total burn-up $5.2 \times 10^{+20}$ fiss. cm^{-3}; values reported lower than actual.
▽	64-2	396-942		Same as above.	Same as above except total exposure $2.2 \times 10^{+20}$ - $2.6 \times 10^{+20}$ Nvt and total burn-up $6.6 \times 10^{+20}$ fiss. cm^{-3}.
▷	64-2	356-693		Same as above.	Same as above except total thermal exposure $15.6 \times 10^{+20}$ - $15.9 \times 10^{+20}$ Nvt and total burn-up $28 \times 10^{+20}$ fiss. cm^{-3}.
□	63-9	2153-2713		Short time capsule containing 95% dense UO_2 pellets.	Irradiated 20 min at thermal performance levels sufficient to produce UO_2 central melting; data determined indirectly from measurements of the radial temperature profile established by grain growth and size distribution.
○	64-3	328-1146	±3.8	$UO_{2.012 \pm 0.002}$; 0.0596 excess O_2, 0.03 Ca, 0.0265 Fe, 0.0062 Nb, 0.004 C, 0.0037 Sn, 0.003 N, 0.002 > F, 0.0002 - 0.0014 Cr, 0.0002 - 0.0011 Ni, 0.0006 Al, 0.00056 Mo, 0.0004 > Sn, 0.001 > Si, 0.0001 Na, 0.0001 Cd, 0.0005 > Pb, 0.00005 > Ag, 0.00005 > B, 0.00005 > Eu, 0.00003 > Gd, and 0.00002 Cu; grain dia 10 to 20 μ; density 93.4% of theoretical.	Prepared by cold-pressing nuclear grade depleted UO_2 powder and by sintering in hydrogen at 1850 C for 4 hrs; sample contained open and closed pores.

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THERMAL CONDUCTIVITY -- URANIUM DIOXIDE (continued)

REFERENCE INFORMATION

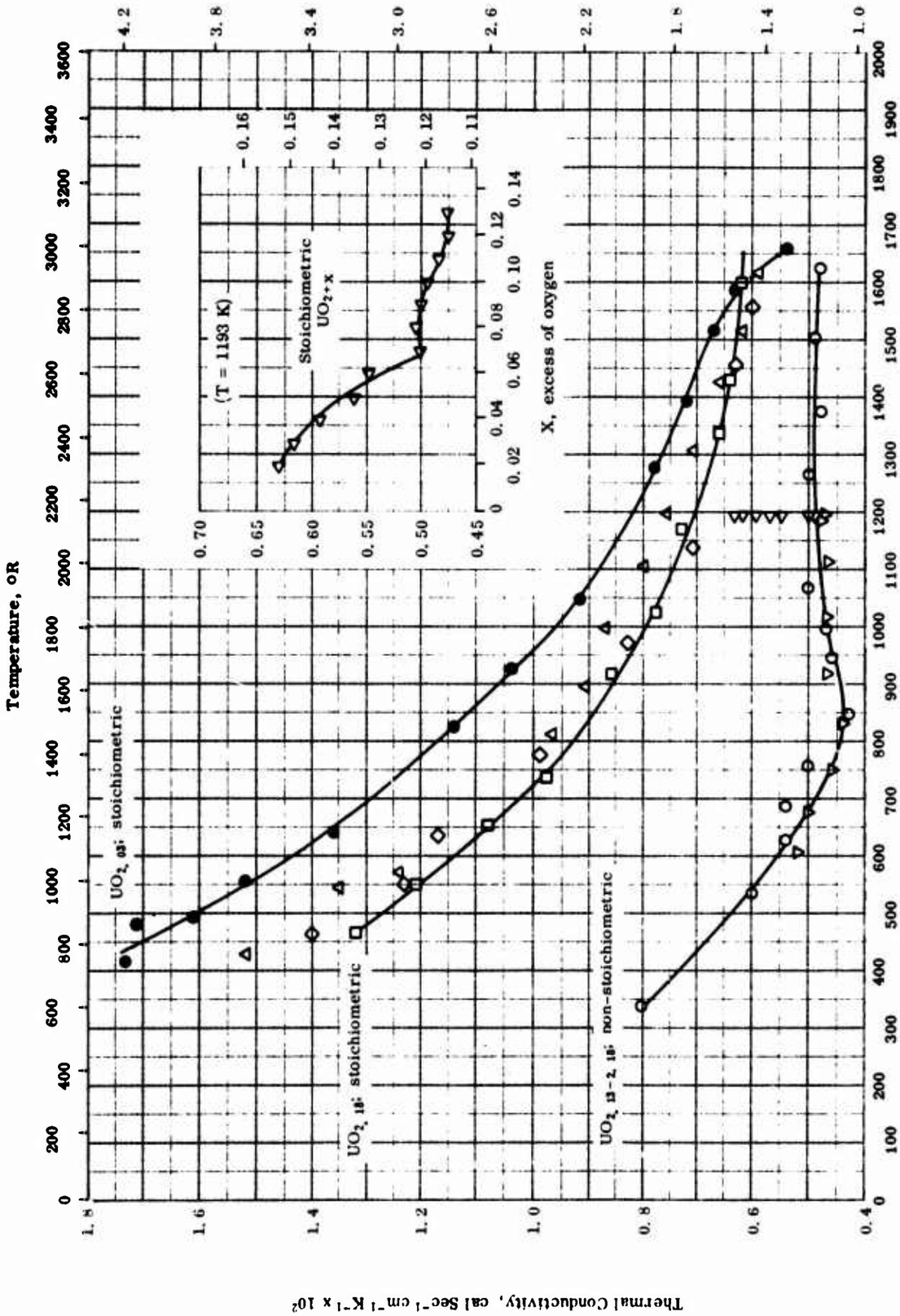
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
△	64-3	328-1146	±3.8	Same as above.	Same as above; data corrected for core expansion and porosity.
◁	64-3	327-1074	±3.8	$UO_{2.006 \pm 0.002}$; same as above.	Same as above except data not corrected for core expansion and porosity.
◇	64-3	327-1074	±3.8	Same as above.	Same as above except data corrected for core expansion and porosity.
▼	64-3	373-1465	±3.8	Same as above.	Same as above except apparatus was heated above 1000 C; data not corrected for core expansion and porosity.
▶	64-3	373-1465	±3.8	Same as above.	Same as above except data corrected for core expansion and porosity.
◀	64-3	382-1569	±3.8	Same as above.	Same as above except the apparatus was cycled between 900 to 1350 C several times and a max of 1400 C reached.
▲	64-3	382-1569	±3.8	Same as above	Same as above except data corrected for core expansion and porosity.
◘	61-7	1106-2385	<15	Prepared from Mallinckrodt PWR-grade powder; 85% of theoretical density.	Pressed and sintered in dry hydrogen and then ground flat on both sides.

(Continued onto next page)

TPRC

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◆	62-9	461-1161	5	$UO_{2.002}$; mixture of single crystal particles with 60% + 4 mesh, 30% - 10 + 20 mesh, 6% - 35 + 65 mesh, and 4% - 100 + 200 mesh; density 9.529 g cm^{-3}.	Compacted vibrationally; measured in argon.
◆	62-9	546-705	5	Polycrystalline high-purity UO_2 with density 10.59 g cm^{-3}.	Die pressed discs with fine hairline cracks; sintered in hydrogen at 1650 - 1800 C; measured in argon.
■	62-9	526-1317	5	$UO_{2.006}$; high purity polycrystalline with density 10.22 g cm^{-3}.	Machined from hydrostatically pressed sample and sintered in H_2 at 1650 - 1800 C; measured in argon.
◆	62-9	363-1007	5	$UO_{2.002}$; polycrystalline with density 9.55 g cm^{-3}.	Extruded to near final size, hydrostatically pressed, and then sintered in hydrogen at 1650 - 1800 C; measured in vacuum.
●	62-9	416-1489	5	$UO_{2.003}$; single crystal with density 10.89 g cm^{-3}.	Prepared by commercial arc-fusion process; measured in vacuum.



THERMAL CONDUCTIVITY -- URANIUM DIOXIDE
(With excess oxygen)

THERMAL CONDUCTIVITY -- URANIUM DIOXIDE
(With excess oxygen)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-8	338-1623	±6	$UO_{2.18}$; non-stoichiometric; grain size (after test) 15 μ.	Prepared from $UO_{2.2}$ powder by cold-pressing at 167 lb in^{-2}, hydrostatically pressing at 20,000 lb in^{-2}, and sintering at 1400 C in N_2 for 2 hrs.
□	61-8	466-1598	±6	$UO_{2.18}$; stoichiometric; density 10.50 g cm^{-3}.	Same preparation as above except followed by 2 hrs reduction in H_2 at 1400 C after sintering; measured in 0.85 N_2 and 0.15 H_2 atm.
△	61-8	430-1613	±6	$UO_{2.03}$; stoichiometric; grain size (after test) 2.5 μ; density 10.48 g cm^{-3}.	Prepared from $UO_{2.03}$ and cranko powder and enriched to 1.28 Co; same method of preparation and heat treatment as the above sample.
▽	61-8	605-1196	±6	Same as above except non-stoichiometric.	The above sample oxidized to $UO_{2.13}$.
◇	61-8	463-1555	±6	Stoichiometric; grain size (after test) 17.5 μ; density 10.42 g cm^{-3}.	Prepared from $UO_{2.2}$ powder with 1 mole % TiO_2 added as an acid for sintering; same method of preparation and heat treatment as the above sample.
●	61-8	419-1656	±6	Stoichiometric $UO_{2.03}$; grain size (after test) 6.6 μ; density 10.34 g cm^{-3}.	Prepared from $UO_{2.03}$ powder by cold-pressing at 167 lb in^{-2} and hydrostatically pressing at 20,000 lb in^{-2}; pre-sintered at 1400 C for 1 hr in H_2 and then final sintered at 1700 C for 10 hrs in cracked ammonia; measured in 0.85 N_2 and 0.15 H_2 atm.

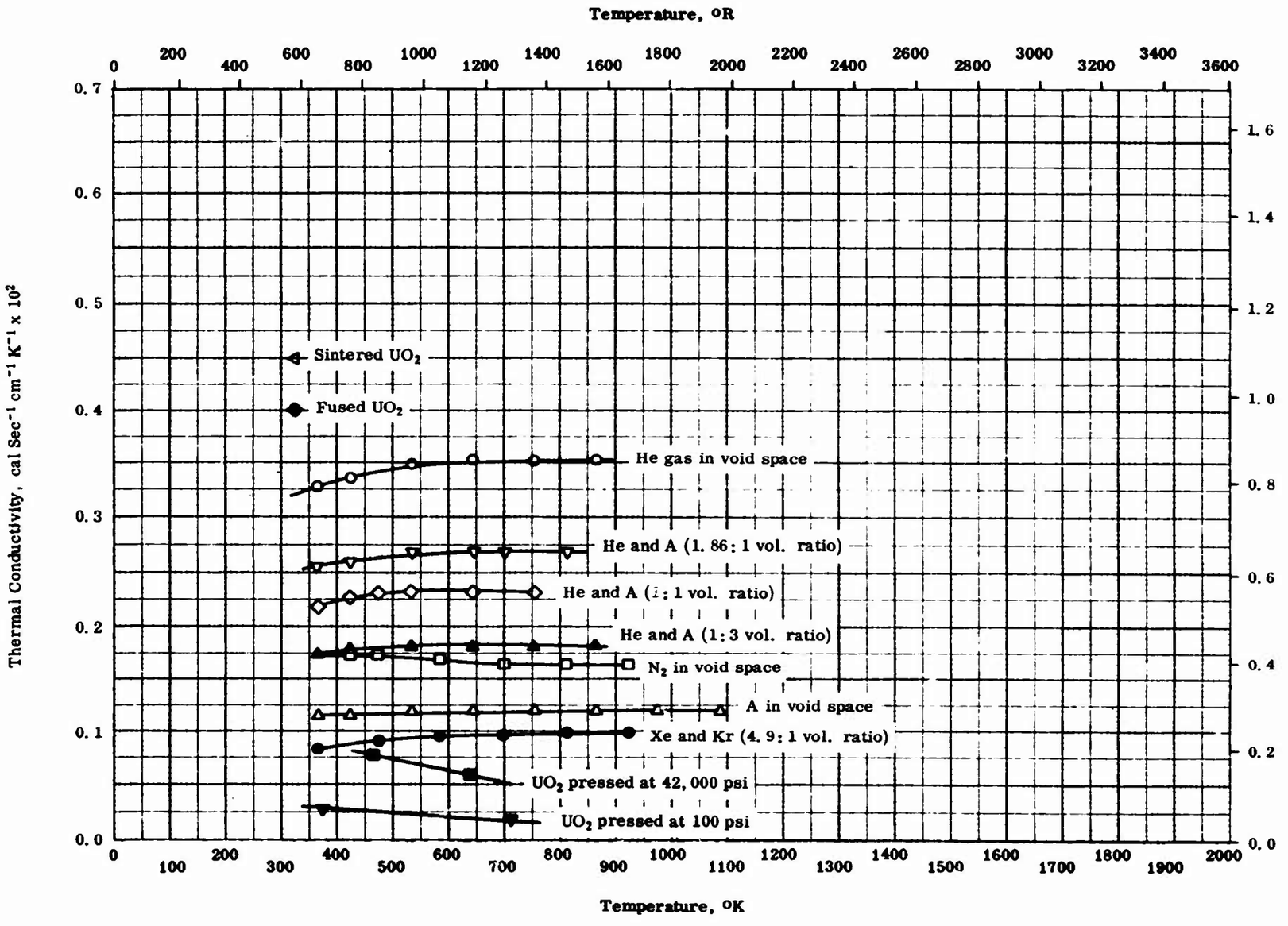
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THERMAL CONDUCTIVITY -- URANIUM DIOXIDE (continued)
(With excess oxygen)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◁	61-8	1193	± 6	UO_{2+x}; stoichiometric $UO_{2.00}$; grain size (after test) 2.5 μ; density 10.48 g cm^{-3}.	Prepared from $UO_{2.00}$ and cranko powder and enriched to 1.28 Co by cold-pressing at 167 lb in^{-2}, and hydrostatically pressing at 20,000 lb in^{-2}; sintered at 1400 C in N_2 for 2 hrs.

TPRC



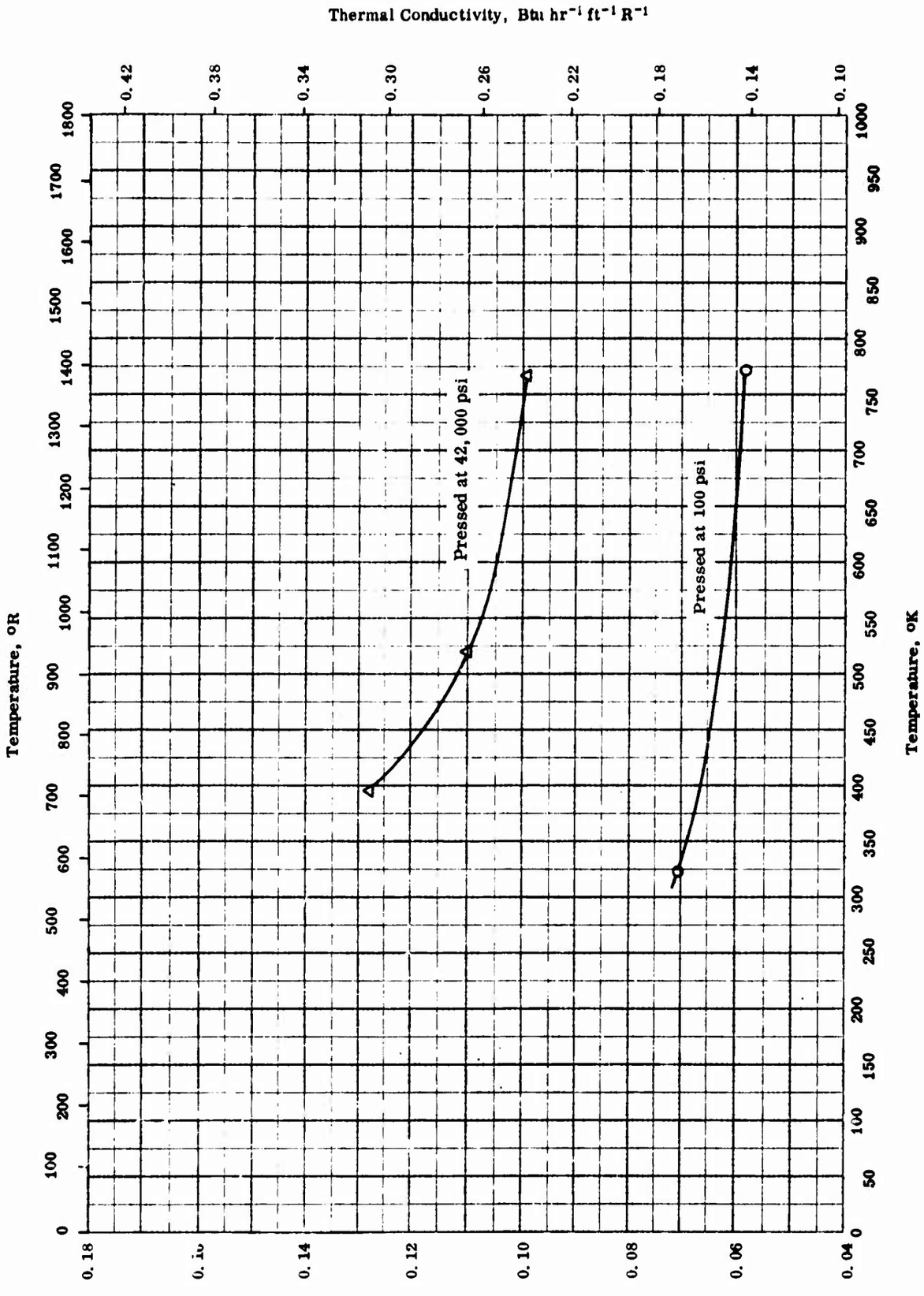
THERMAL CONDUCTIVITY -- URANIUM DIOXIDE POWDER

THERMAL CONDUCTIVITY -- URANIUM DIOXIDE POWDER

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	55-11	367-867		Uranium Oxide Powder; void fraction 0.405; density 398 lb ft^{-3}; 0% retained on 0.0059 in. mesh, 59% on 0.0041 in. mesh, and 41% on 0.000748 in. mesh.	Helium in void space at 59.3 - 136.9 psia.
□	55-11	422-922		Same as above.	Nitrogen in void space at 49.3 - 83.3 psia.
△	55-11	367-1089		Same as above.	Argon in void space at 44.3 - 94.4 psia.
◇	55-11	367-756		Same as above.	Gas mixture of helium and argon in void space with vol ratio 0.953 to 1 and pressure level 39.4 - 96.3 psia.
▽	55-11	367-811		Same as above.	Gas mixture of helium and argon in void space with vol ratio 1.857 to 1 and pressure level 47.3 - 84.3 psia.
●	55-11	367-922		Same as above.	Gas mixture of xenon and krypton in void space with vol ratio 4.898 to 1 and pressure level 18.8 - 74.3 psia.
▲	55-11	367-867		Same as above.	Gas mixture of helium and argon in void space with vol ratio 0.333 to 1 and pressure level 46.3 - 84.3 psia.
▼	55-9	372-717		UO_2 powder.	Pressed at 100 psi.
◪	55-9	467-639		UO_2 powder.	Pressed at 42,000 psi.
◆	55-9	323.4		UO_2 powder.	Fused.
◁	55-9	323.4		UO_2 powder.	Sintered.

TPRC



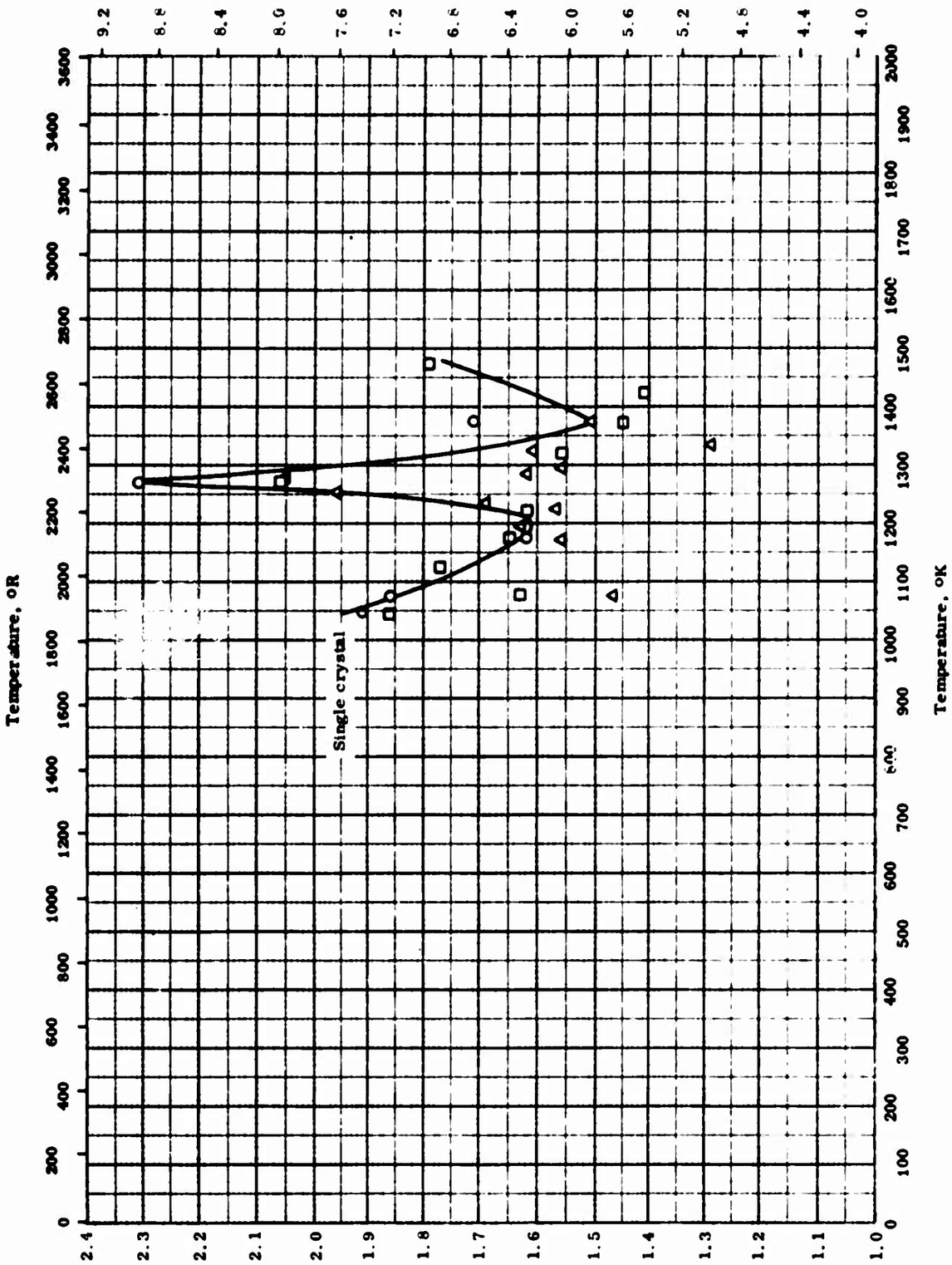
THERMAL CONDUCTIVITY -- TRIURANIUM OCTOXIDE

THERMAL CONDUCTIVITY -- TRIURANIUM OCTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	55-9	323-773		U_3O_8 powder.	Pressed at 100 psi.
Δ	55-9	395-767		U_3O_8 powder.	Pressed at 42, 000 psi.

TPRC



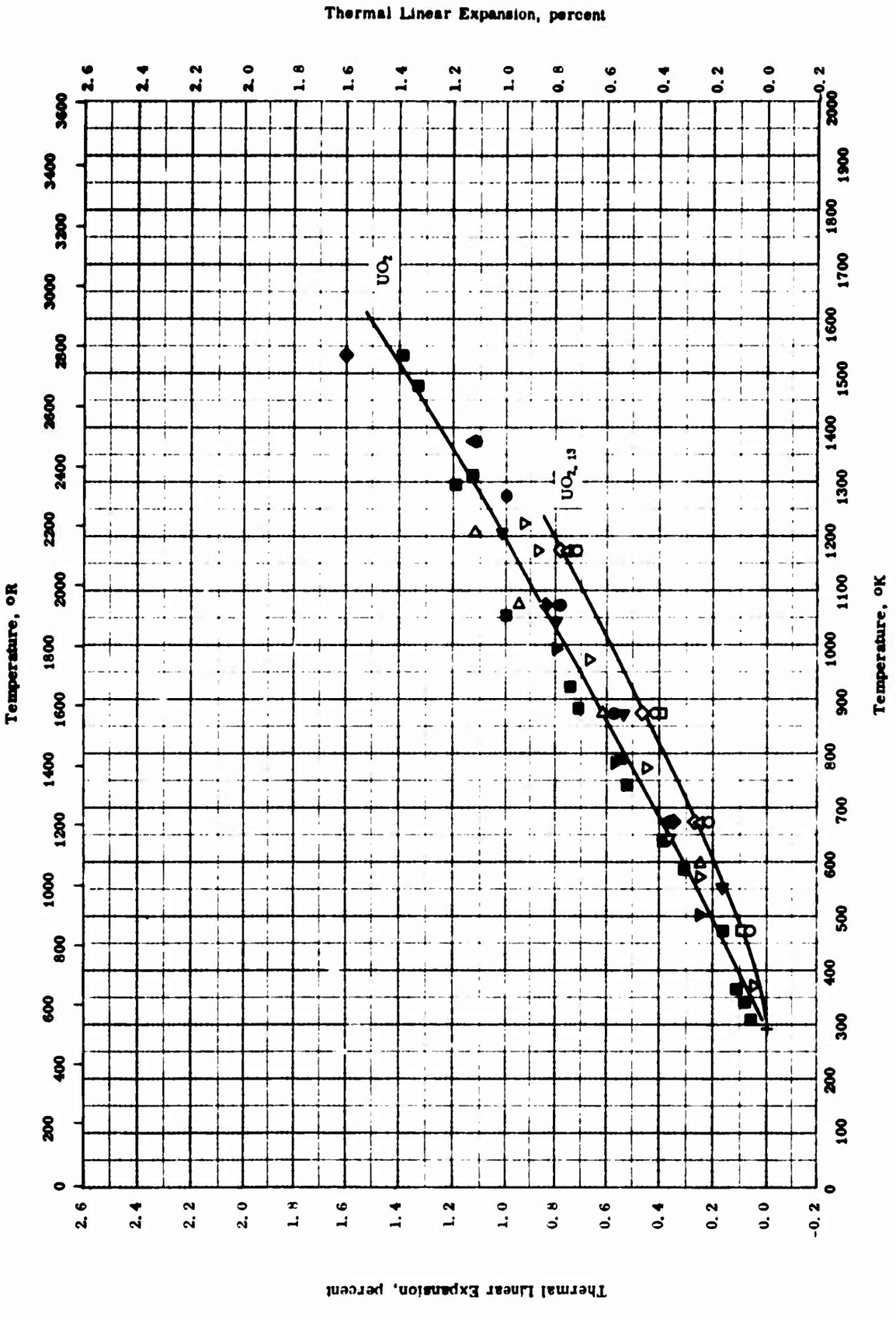
THERMAL DIFFUSIVITY -- URANIUM DIOXIDE

THERMAL DIFFUSIVITY -- URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error σ%	Sample Specifications	Remarks
○	63-6	1048-1373		Single crystal; sample 1/4 in. dia and 30 mil long.	Uncoated.
□	63-6	1043-1473		Same as above.	Second run of the above sample.
△	63-6	1074-1373		Same as above.	Third run of the above sample.

TPRC



THERMAL LINEAR EXPANSION -- URANIUM OXIDES

THERMAL LINEAR EXPANSION -- URANIUM OXIDES

REFERENCE INFORMATION

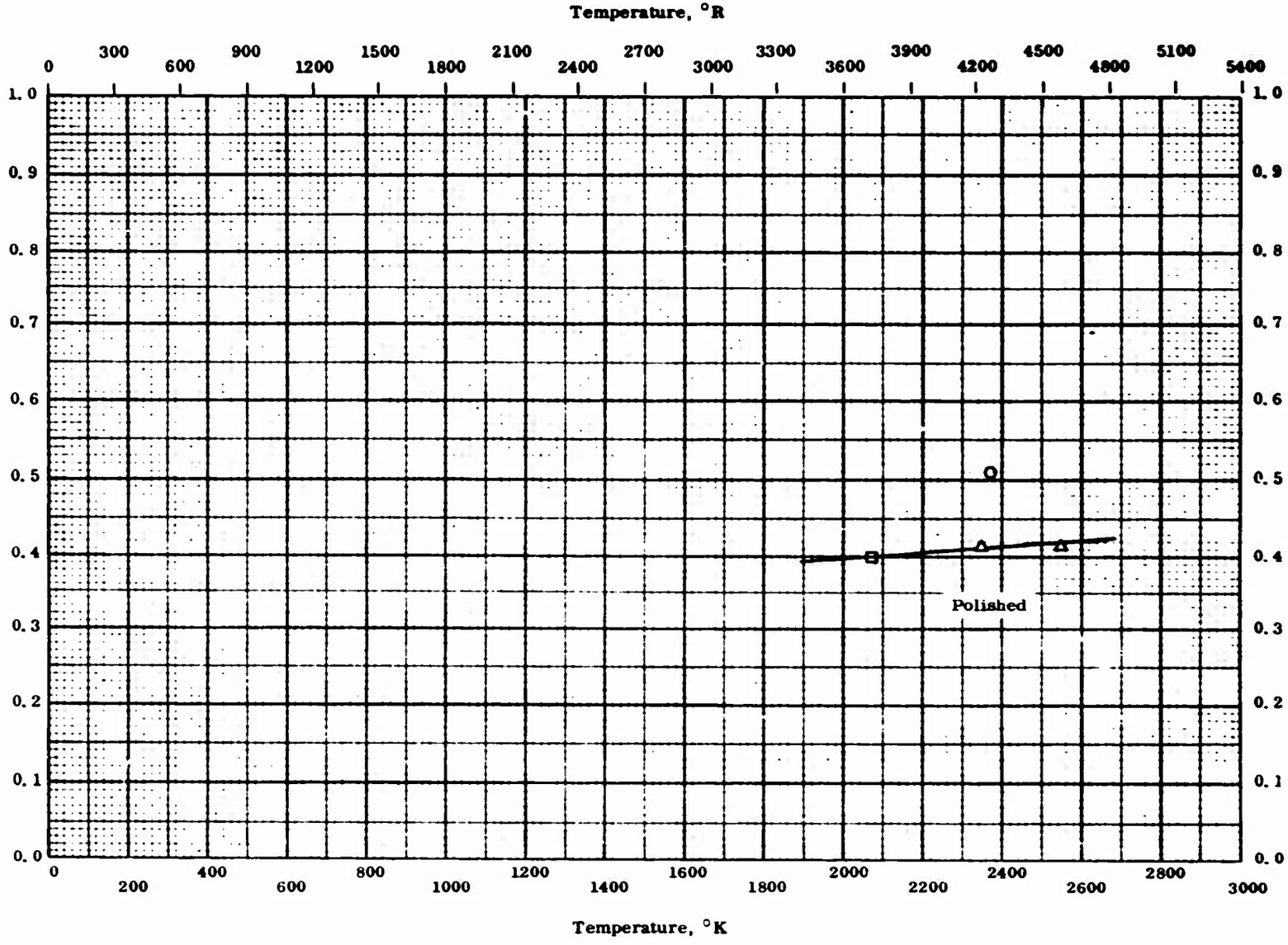
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
●	62-37	293-1373		UO_2.	
▲	62-37	293-1373		98.58 UO_2 and 1.42 BeO (calculated composition based on theoretical density and zero porosity).	
■	63-40	307-1533		UO_2.	Percent expansion calculated from lattice parameters measured in a_o direction.
○	ND-3	293-1173		UO_2; density 450 lb ft^{-3}.	Sintered; tested at 10 C min^{-1} rise in argon atm.
□	ND-3	293-1173		Same as above.	Sintered; tested at 3.5 C min^{-1} rise in argon atm.
△	ND-3	293-1173		$UO_{2.13}$; density 533 lb ft^{-3}.	Sintered; tested at 10 C min^{-1} rise in argon atm.
◇	ND-3	293-1173		$UO_{2.13}$; density 631 lb ft^{-3}.	Sintered; tested at 3.5 C min^{-1} rise in argon atm.
▽	56-20	293-1223		99.8 UO_2, 0.083 MgO, 0.002 Al_2O_3, and 0.001 each Cuo, Fe_2O_3, SiO_2; density 574 lb ft^{-3}.	Slip cast and fired to 1750 C in H_2 atm; tested at 205 C hr^{-1} rise.
▼	52-24	293-993		UO_2.	X-ray diffraction method.
◆	55-32	293-1533		UO_2; 0.001 - 0.01 each Al, Fe, 0.0001 - 0.001 each Ca, Mg, and 0.0001 Cu.	Arc fused, milled 20 hrs, 1 Carbowax added, pressed at 10,000 psi, hydrostatically pressed at 45,000 psi, matured in argon atm for 30 min at 2000 C; plotted average of two heating and cooling runs within 3%.
◁	52-25	293-643		UO_2; 85% theoretical density.	Pressed from powder and sintered at 1950 C in H_2 atm.

(Continued onto next page)

TPRC

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◀	54-36	273-1206		UO_2; prepared from Springfields UO_2 powder; density 624 lb ft^{-3}. [Author's design. : Sample 1]	Pressed at 20, 000 psi and sintered 3 hrs at 1400 C in argon.
▷	54-36	273-1206		Same as above. [Author's design.: Sample 2]	Same as above.



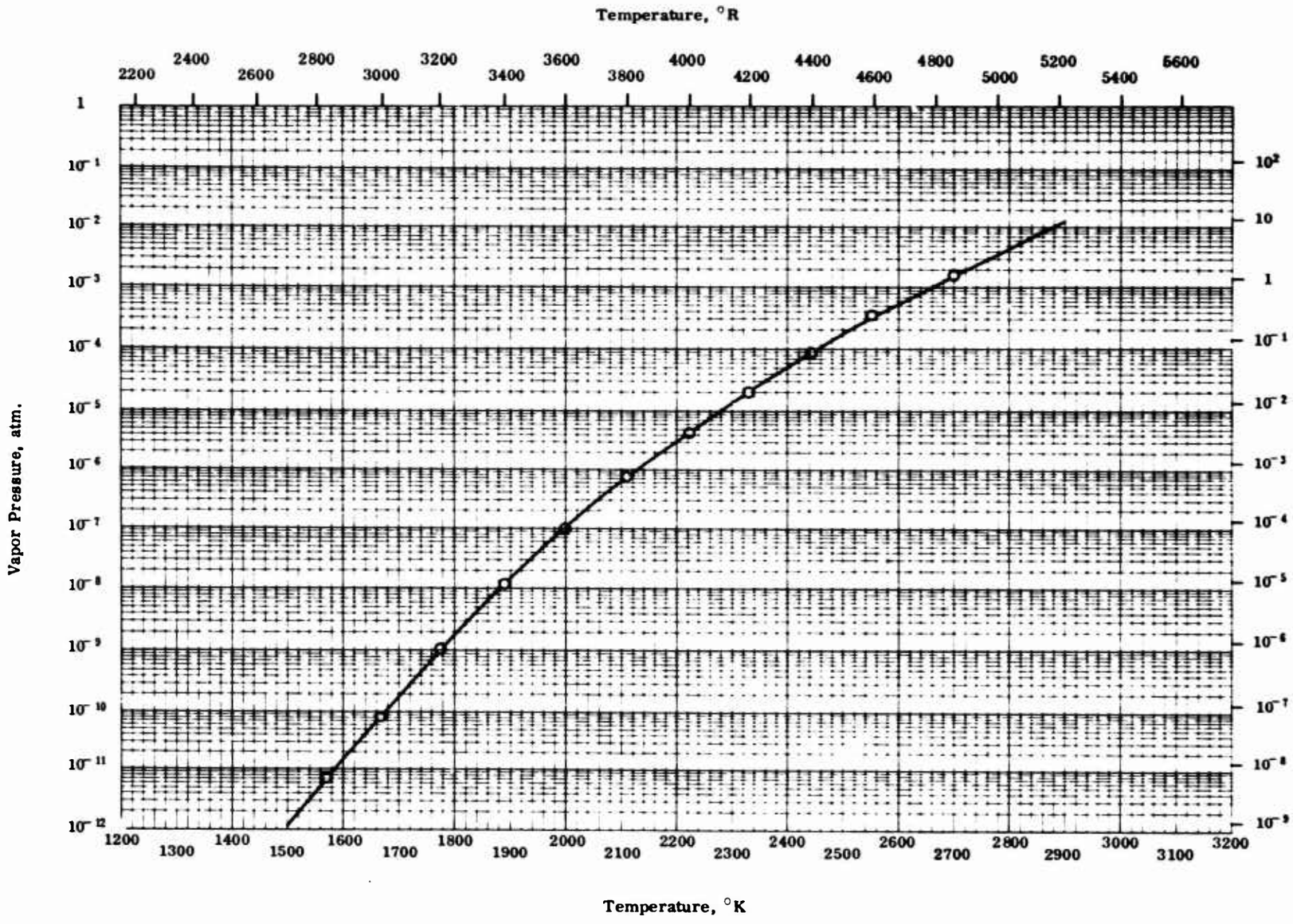
NORMAL SPECTRAL EMITTANCE -- URANIUM DIOXIDE

TPRC

NORMAL SPECTRAL EMITTANCE -- URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
○	58-16	0.65	2373	6	UO_2, pure, powdered material.	Measured in vacuum.
□	58-16	0.65	2073	5	UO_2, pure.	Polished; measured in vacuum.
△	58-16	0.65	M.P ± 100	6	UO_2, pure.	Polished; measured in vacuum.



VAPOR PRESSURE -- URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	56-5	1573-2700		UO_2.	W cell.

TPRC

PROPERTIES OF VANADIUM OXIDES

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density.	3.357*	210*
Melting Point	963	1733
Heat of Sublimation	2000_{0K}**	3600_{0K}**

*For V_2O_5 only; Handbook of Chemistry and Physics (Ref. 64-16)
**For VO only.

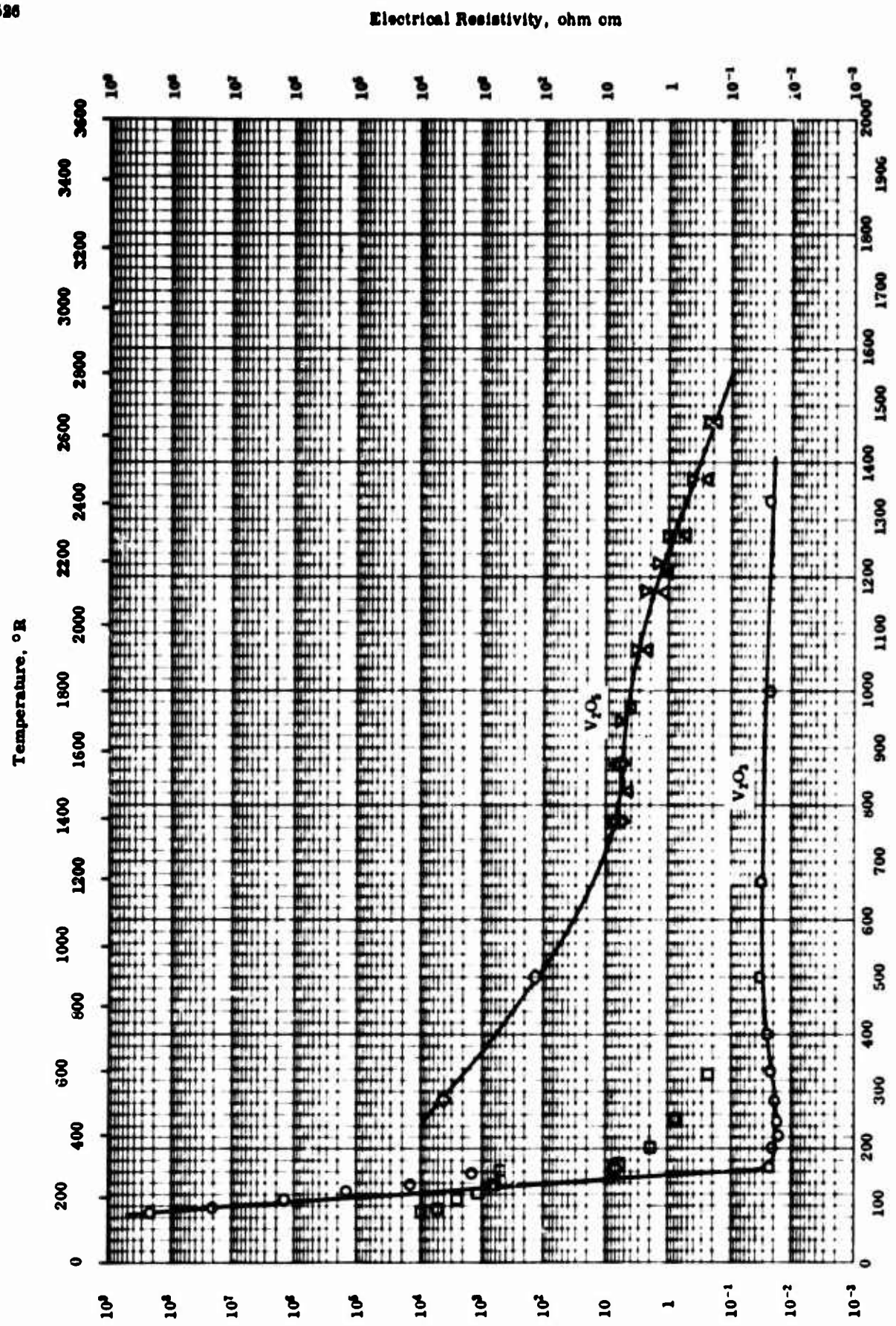
REPORTED VALUES

Melting Point	K	R
△ V_2O_5	945	1701
▽ V_2O_5	947 ±5	1704 ±9
◇ V_2O_5	955 ±5	1719 ±9
◁ V_2O_5	963	1733
▷ V_2O_5	963	1733

Heat of Sublimation	cal g^{-1}	Btu lb^{-1}
○ VO	2021^0_{0K} ± 4	3638^0_{0R} ± 8
□ VO	1933^0_{0K} ± 9	3479^0_{0R} ± 16

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	56-3	0		VO.	Δh_s from vapor pressure data.
□	56-3	0		VO.	Same as above.
△	56-23	945		V_2O_5.	
▽	56-24	942-952		99.94 V_2O_5.	
◇	57-26	950-960		V_2O_5.	
◁	59-11	963		V_2O_5.	
▷	62-22	963		Pure V_2O_5.	

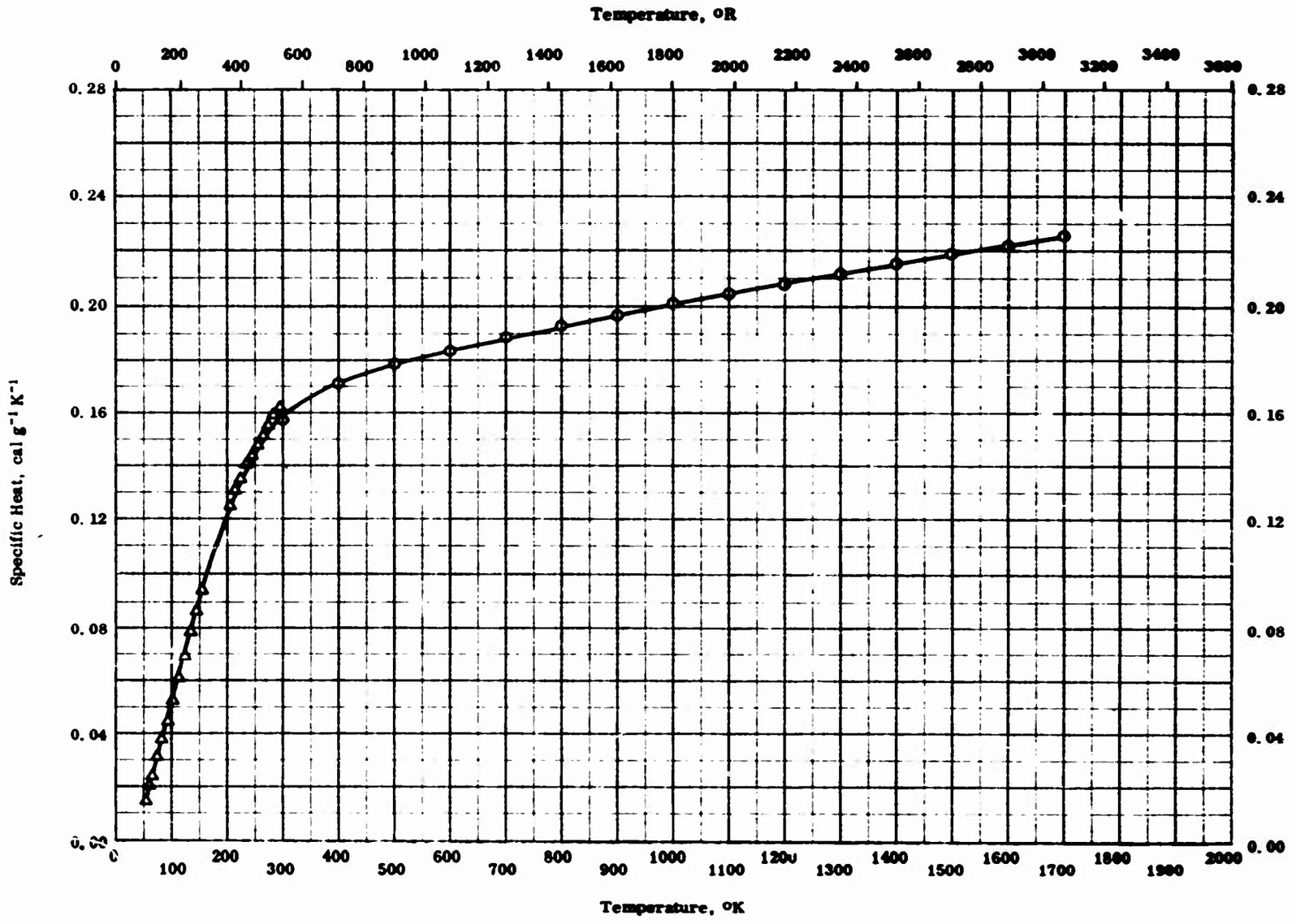


ELECTRICAL RESISTIVITY -- VANADIUM OXIDES

ELECTRICAL RESISTIVITY -- VANADIUM OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	49-4 also 52-11	91-1333		V_2O_3.	Compressed; sintered at 1100 C.
□	49-4 also 52-11	91-333		Same as above.	Compressed; sintered at 1800 C.
△	57-15	773-1473	± 10	V_2O_3. Russian brand (Ch. D. A.)	Heating.
▽	57-15	773-1473		Same as above.	Cooling.
◇	55-18	286-500		V_2O_3; 0.01 ea. Te, Si, and 0.001 ea. Al, Cr, Cu; 98 of V_2O_3 coarse crystal; 2% skeleton type crystal stringers.	

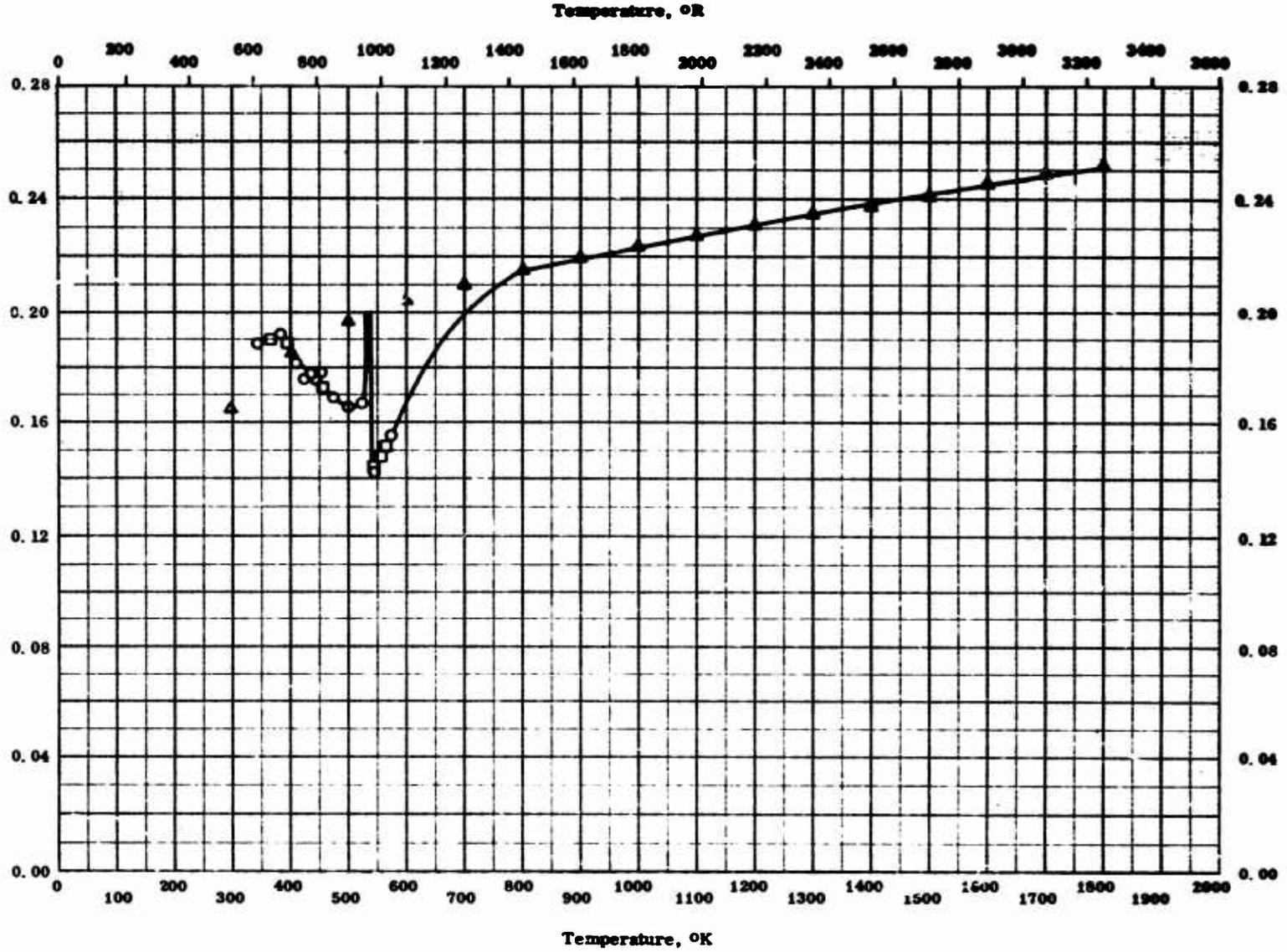


SPECIFIC HEAT -- VANADIUM MONOXIDE

SPECIFIC HEAT -- VANADIUM MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-17	298-1700	0.2	98.2 VO with small quantity V_2O_3.	
Δ	51-11	54-298		98.2 VO with 74.72 V; 0.92 Si, 0.23 NaO, and 0.10 Fe.	



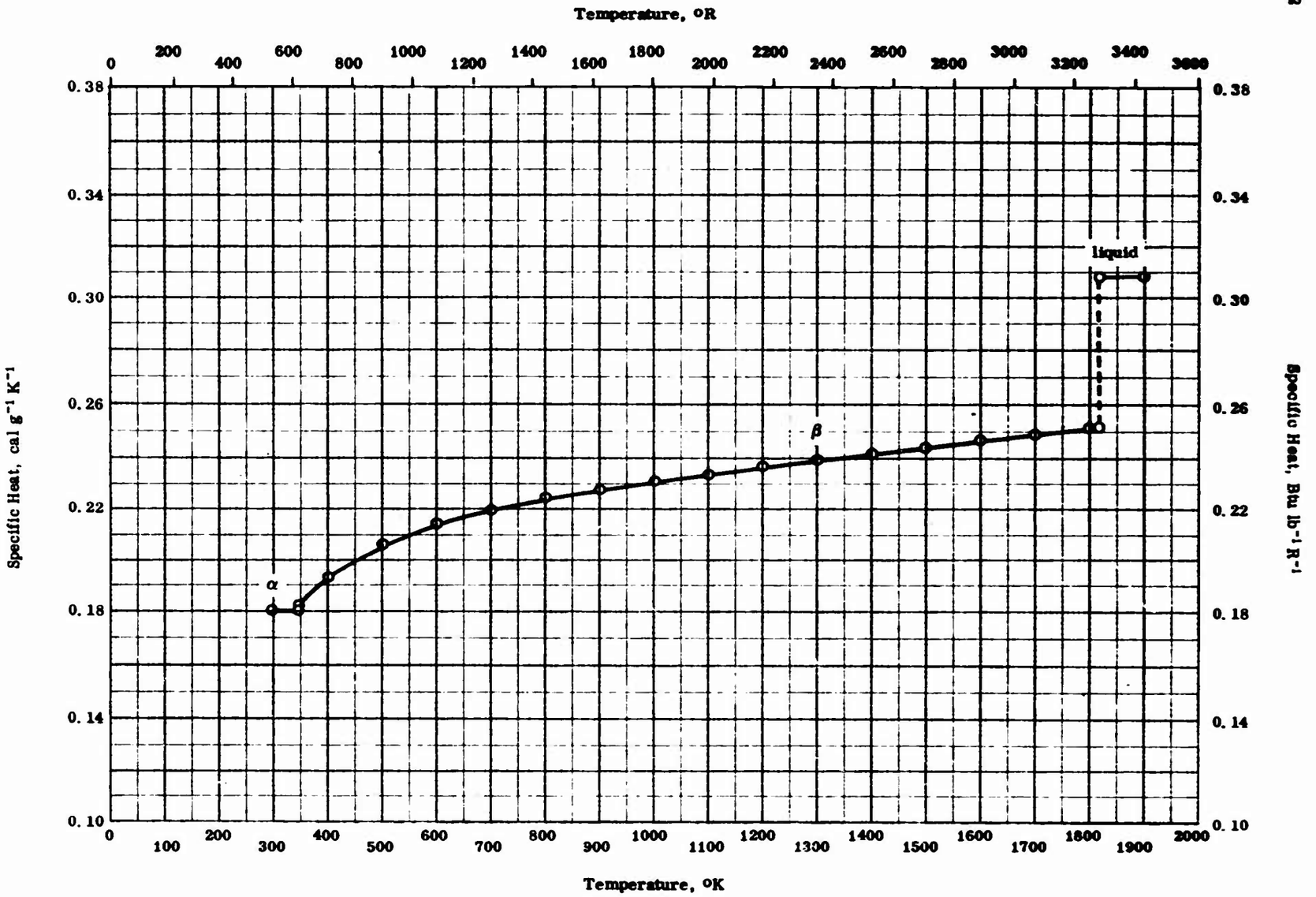
SPECIFIC HEAT -- VANADIUM SESQUIOXIDE

TPRC CRPI

SPECIFIC HEAT -- VANADIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-11	343-573	±3.0	V_2O_3.	
□	51-9	343-573	2.0	V_2O_3.	
△	47-2	298-1800		V_2O_3 with 67.89 V.	Prepared by heating pure V_2O_3 in silica flask at 800 C in a stream of pure hydrogen until no further water vapor was evolved.



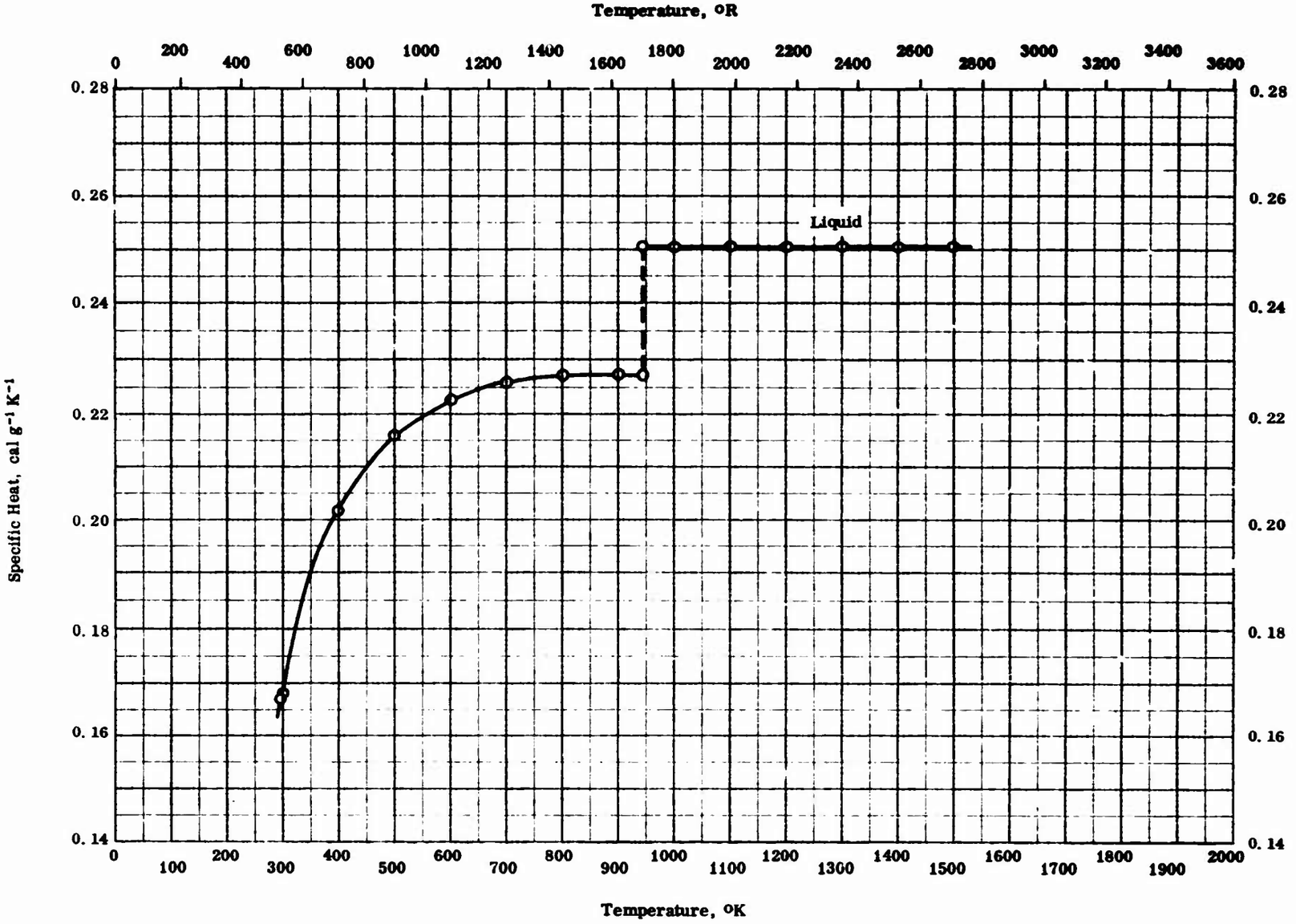
TPRC

SPECIFIC HEAT -- VANADIUM TETROXIDE

SPECIFIC HEAT -- VANADIUM TETROXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	47-2	298-1900		V_2O_4 with 61.45 V.	Prepared from pure vanadium trioxide by controlled oxidation with air in platinum vessel at 300 C; placed in silica flask, evacuated at room temperature, and given prolonged heat treatment below 600 C.



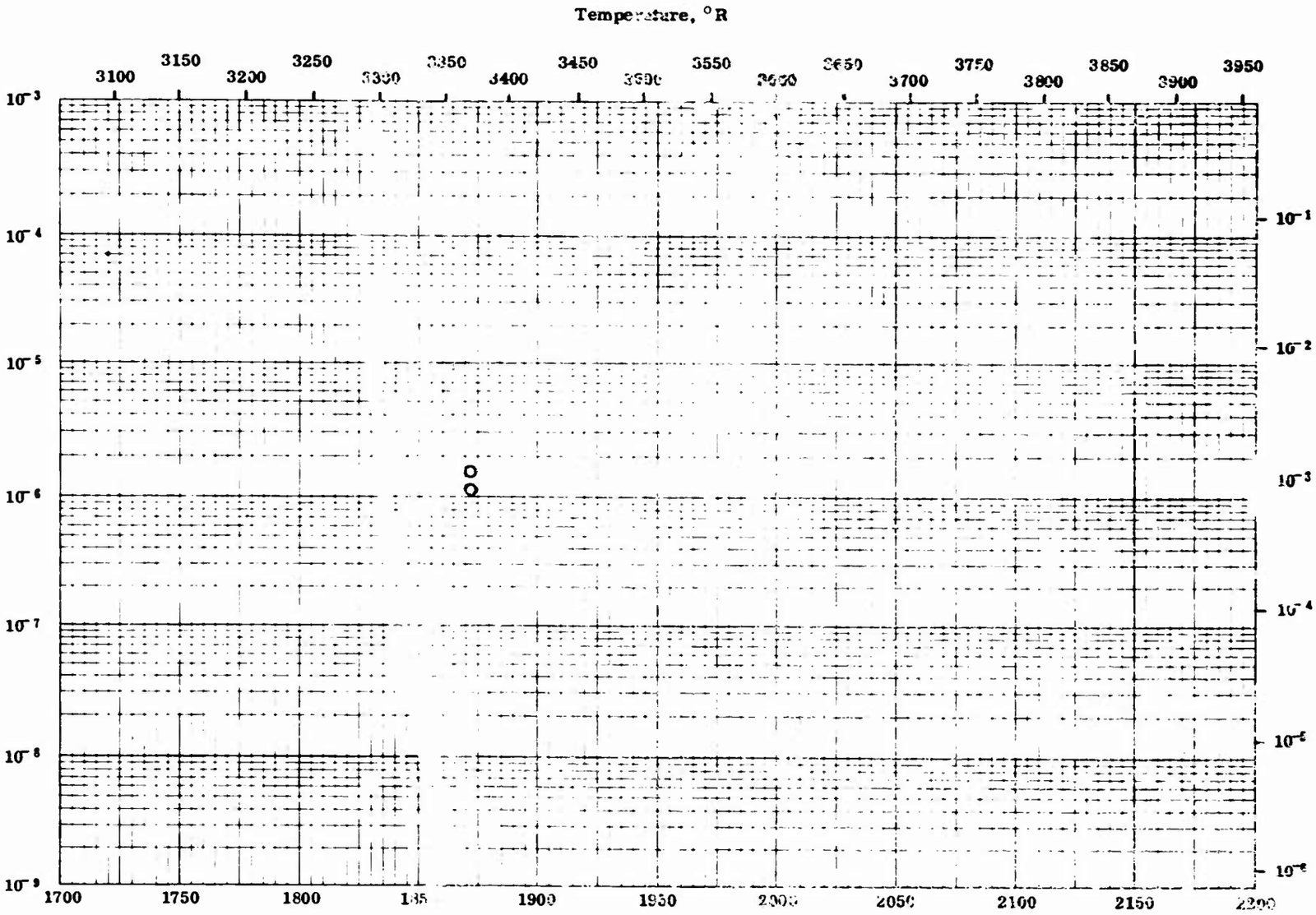
SPECIFIC HEAT -- VANADIUM PENTOXIDE

TPRC

SPECIFIC HEAT -- VANADIUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	47-2	298-1500		V_2O_5 with 55.96 V.	Prepared from purified ammonium vanadate by heating in platinum vessel in a stream of pure hydrogen at 440-460 C for 7 days.



TPRC

VAPOR PRESSURE -- VANADIUM MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	56-3	1872-1873		VO.	$VO_{(s)} \rightarrow VO_{(g)}$.

PROPERTIES OF YTTERBIUM OXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density	9.18	572.8

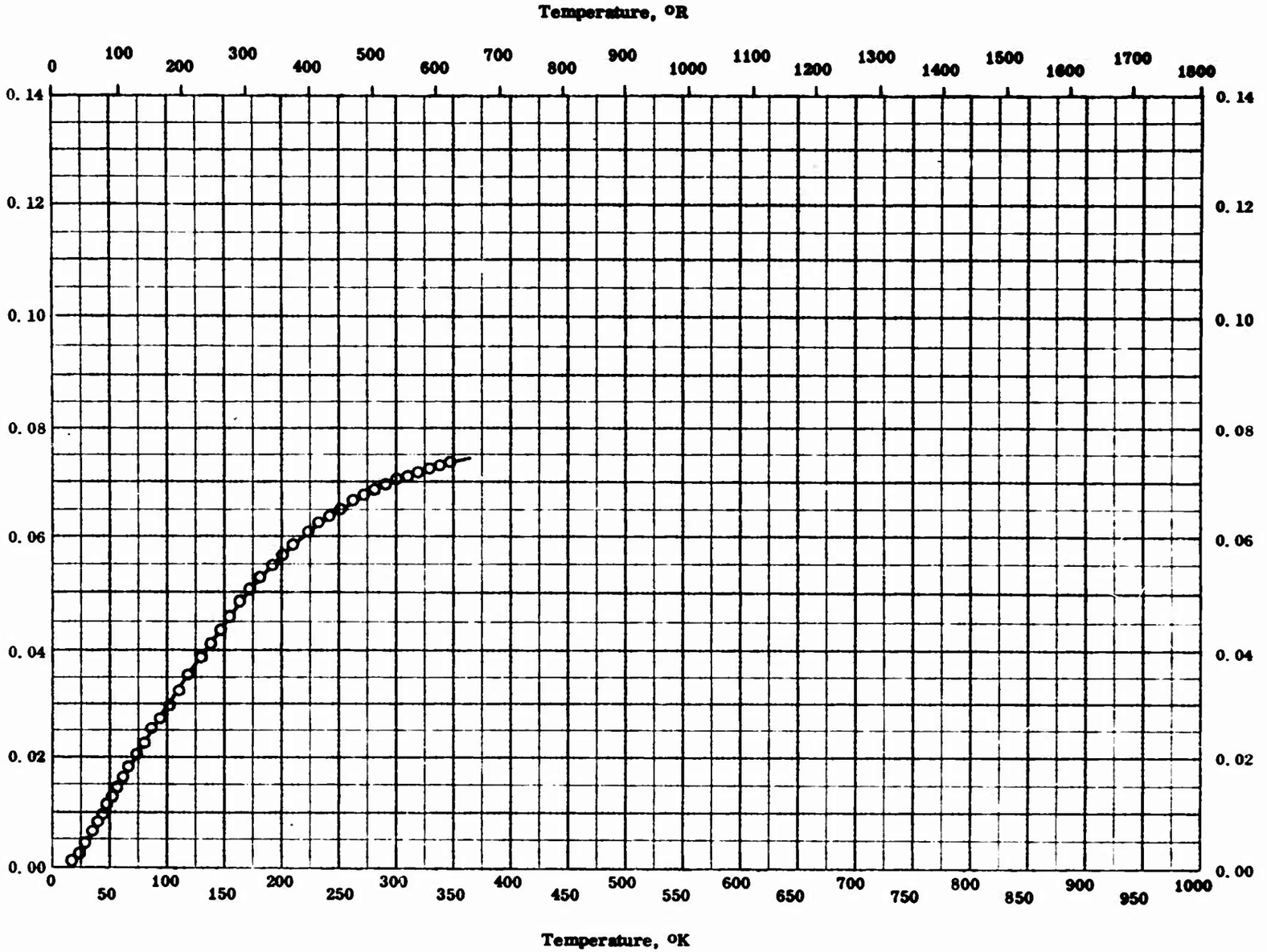
REPORTED VALUES

		$g\ cm^{-3}$	$lb\ ft^{-3}$
Density			
	O	9.18	572.8

PROPERTIES OF YTTERBIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	62-16	298		Yb_2O_3.	

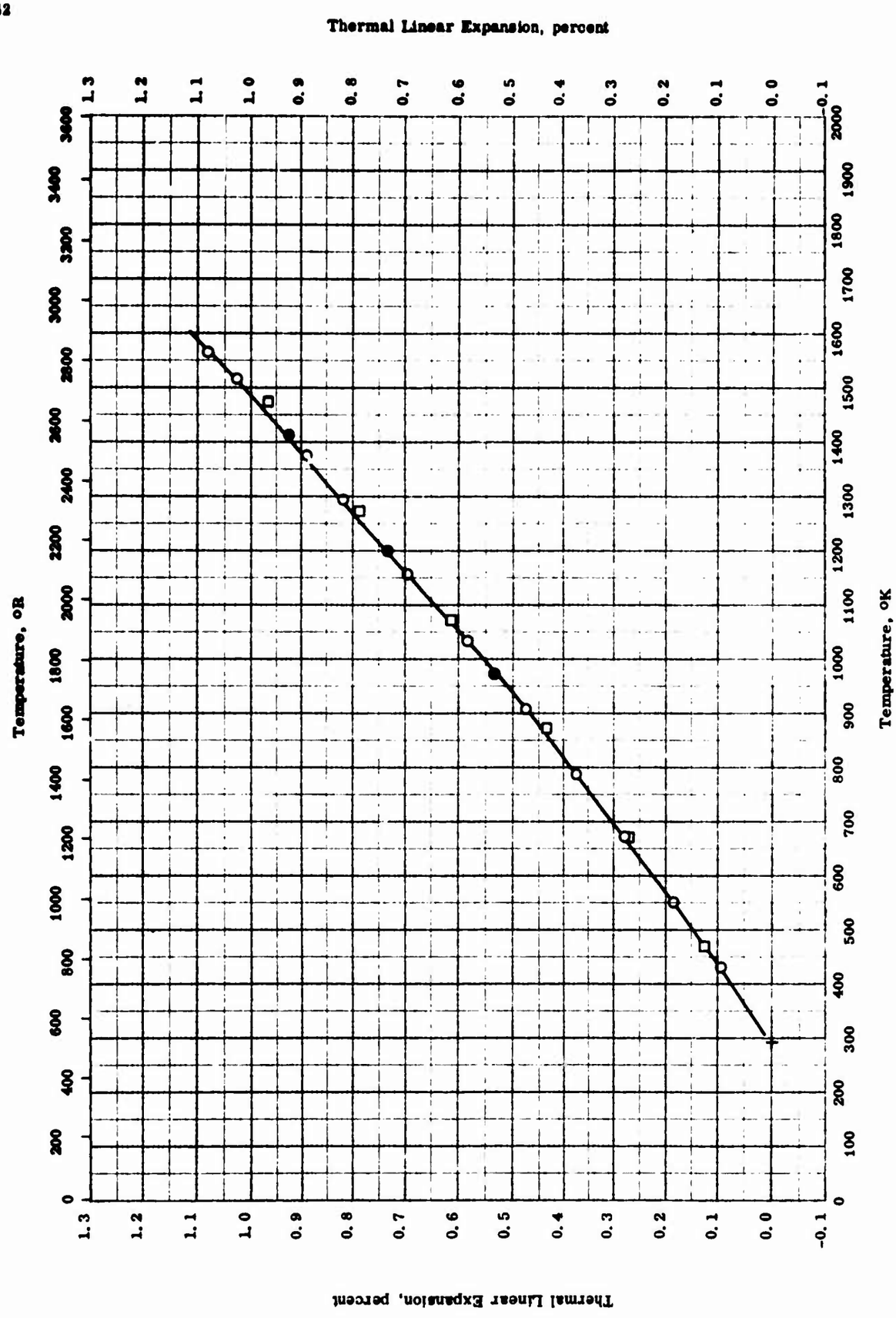


SPECIFIC HEAT -- YTTERBIUM OXIDE

SPECIFIC HEAT -- YTTERBIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	61-13 also 60-12	5-247	0.1	99.9 Yb_2O_3, 0.050 Lu, 0.010 Ca, and 0.010 Si.	Under helium atm.

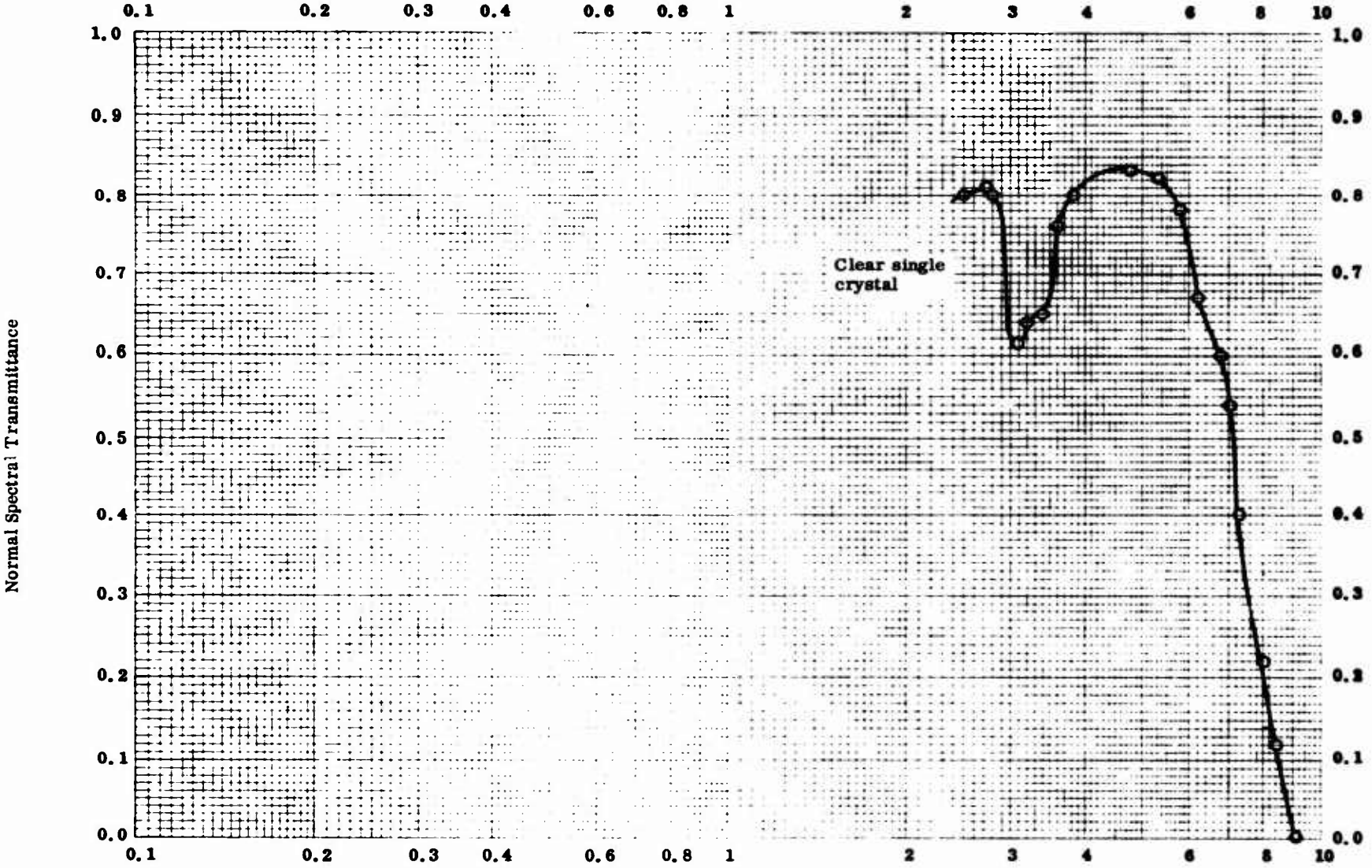


THERMAL LINEAR EXPANSION -- YTTERBIUM OXIDE

THERMAL LINEAR EXPANSION -- YTTERBIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-41	273-1566	1.1-6.0	Yb_2O_3 from Michigan Chemical Co., St. Louis, Mich.; 99.9 Yb_2O_3 in regard to rare-earth content; 0.003 - 0.03 each Ca, Si, Tm, Y, 0.001 - 0.01 each, Pb, Ti, and trace of Fe, Lu, and Mg; cubic, rare-earth oxide type C.	Sintered at 1300 C for 24 hrs, packed into alumina sample holder, resintered at 1400 C for 12 hrs, cooled to 250 C, and placed in a vacuum desiccator for storage; x-ray diffraction method.
●	61-41	973-1566		Same as above.	Cooling cycle for above sample.
□	61-44	298-1473		>99 Yb_2O_3 from Research Chemical, Inc., Burbank, Calif.	X-ray method.



NORMAL SPECTRAL TRANSMITTANCE -- YTTERBIUM OXIDE

NORMAL SPECTRAL TRANSMITTANCE -- YTTERBIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
O	61-31	298	2.5 - 9.1		Yb_2O_3, clear single crystal; 1.89 ± 0.02 mm thickness.	

PROPERTIES OF YTTRIUM OXIDE

MOST PROBABLE VALUES

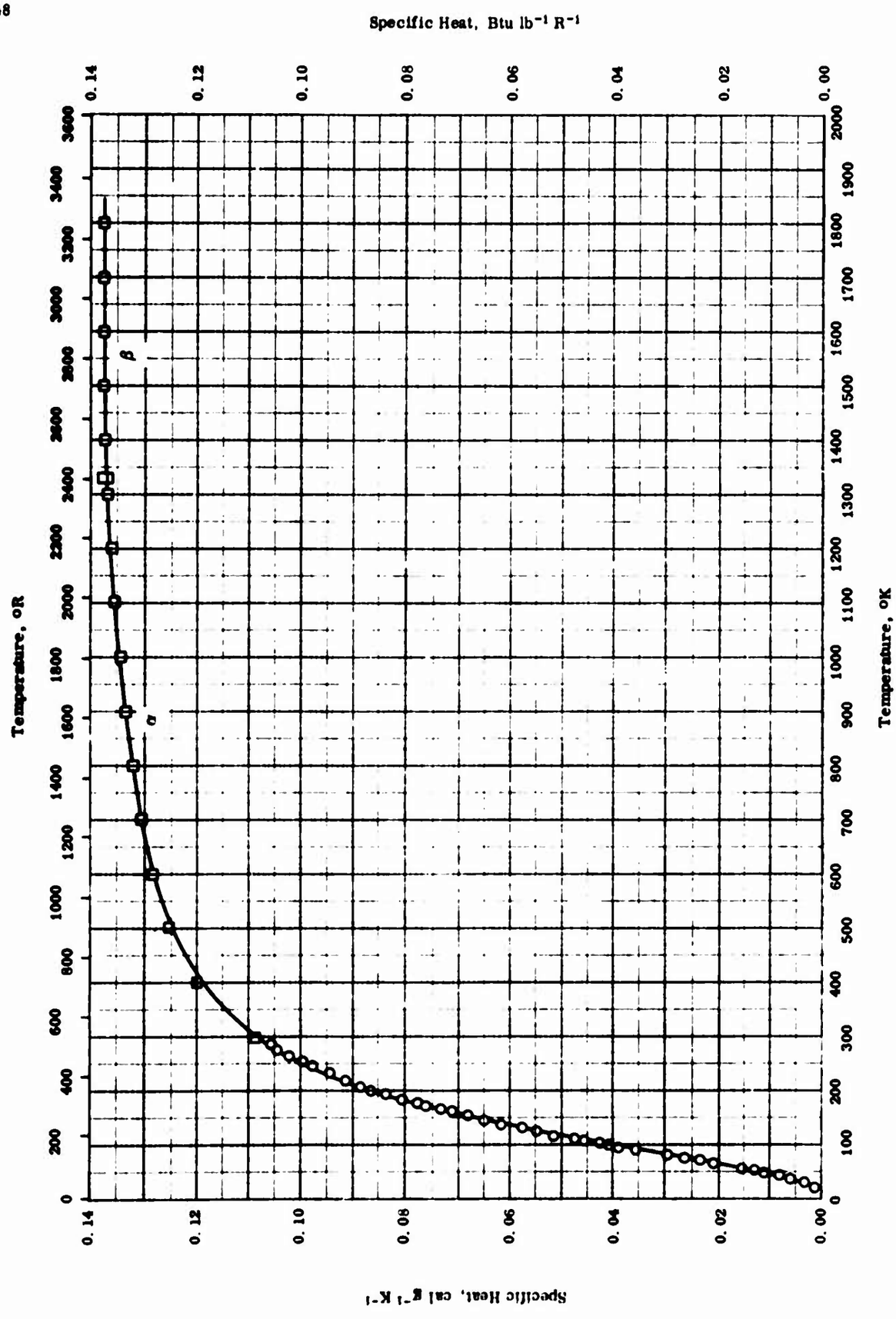
Property	C.G.S. Units	Brit. Eng. Units
Density.	5.05	315.1
Melting Point	2683	4830

REPORTED VALUES

Density		$g\ cm^{-3}$	$lb\ ft^{-3}$
	□	4.46	278
	△	5.05	315.1
Melting Point		K	R
	○	2683	4830

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	49-3	2683		Y_2O_3.	
□	57-22	298		Y_2O_3; 0.1 > each Nb, Cr, Pb, and Zr, 0.05 > each, Al, Co, Cu, Ni, and Si, 0.04 > each Ca and Ce, 0.03 Na, 0.02 > each Ba, Fe, Mg, Mn, Mo, Ti, and V, 0.01 > each K, Li, Pr, Nd, Sm, Tb, and Ho, 0.004 > La, and 0.002 > each Eu, Gd, Er, Tm, Yb, and Be; porosity 0.3%.	Fired at 1000 C; density from weight and volume by water displacement.
△	62-16	298		Y_2O_3.	

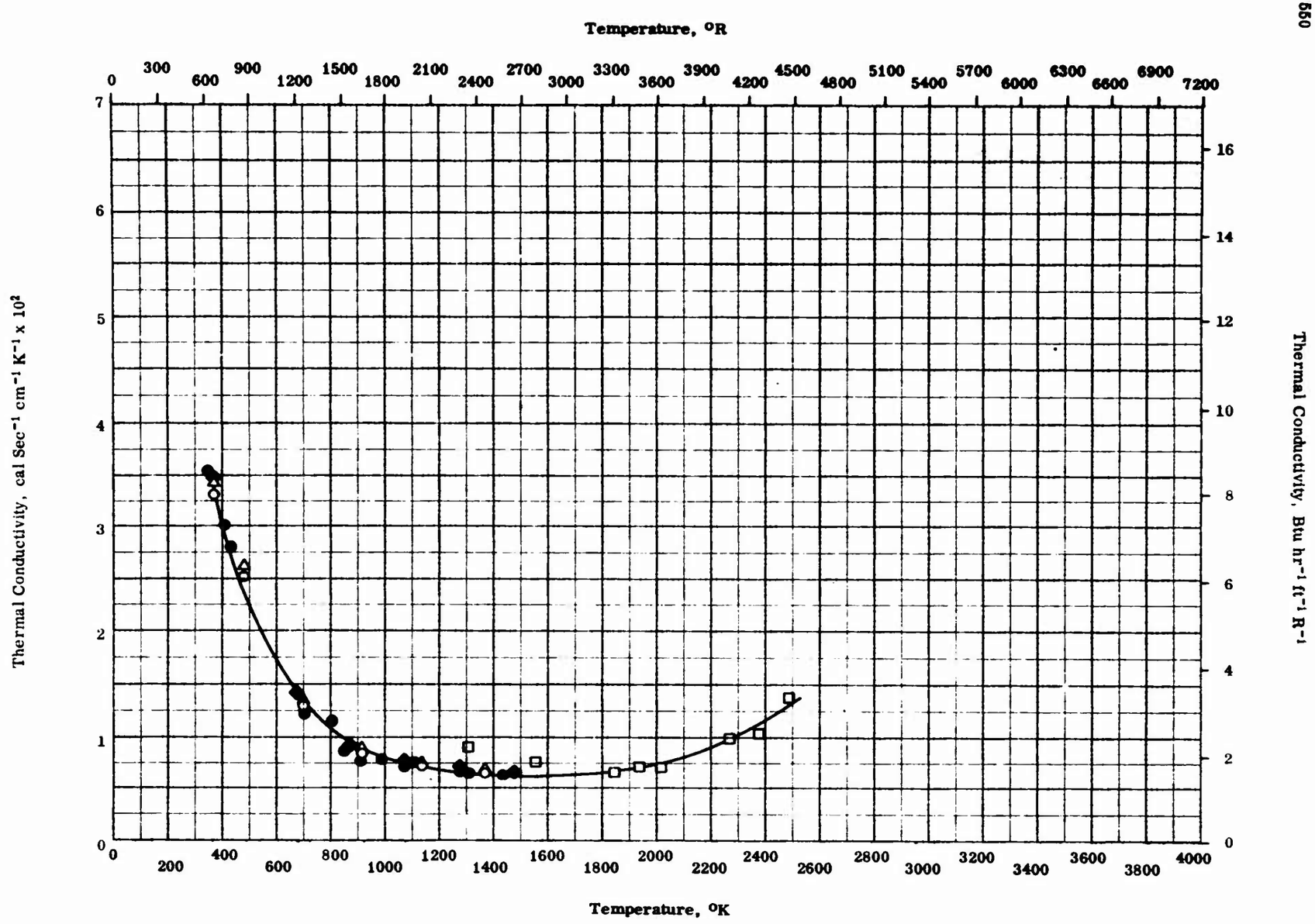


SPECIFIC HEAT -- YTTRIUM OXIDE

SPECIFIC HEAT -- YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	59-6	16-298		99.9 < Y_2O_3, 0.02 > Ho_2O_3, Dy_2O_3, and 0.01 > Cd_2O_3.	Heated to constant weight at 950 C for 24 hrs in air to decompose hydroxides or carbonates.
□	62-11	298-1799	0.2	99.99 Y_2O_3.	Under helium atm.

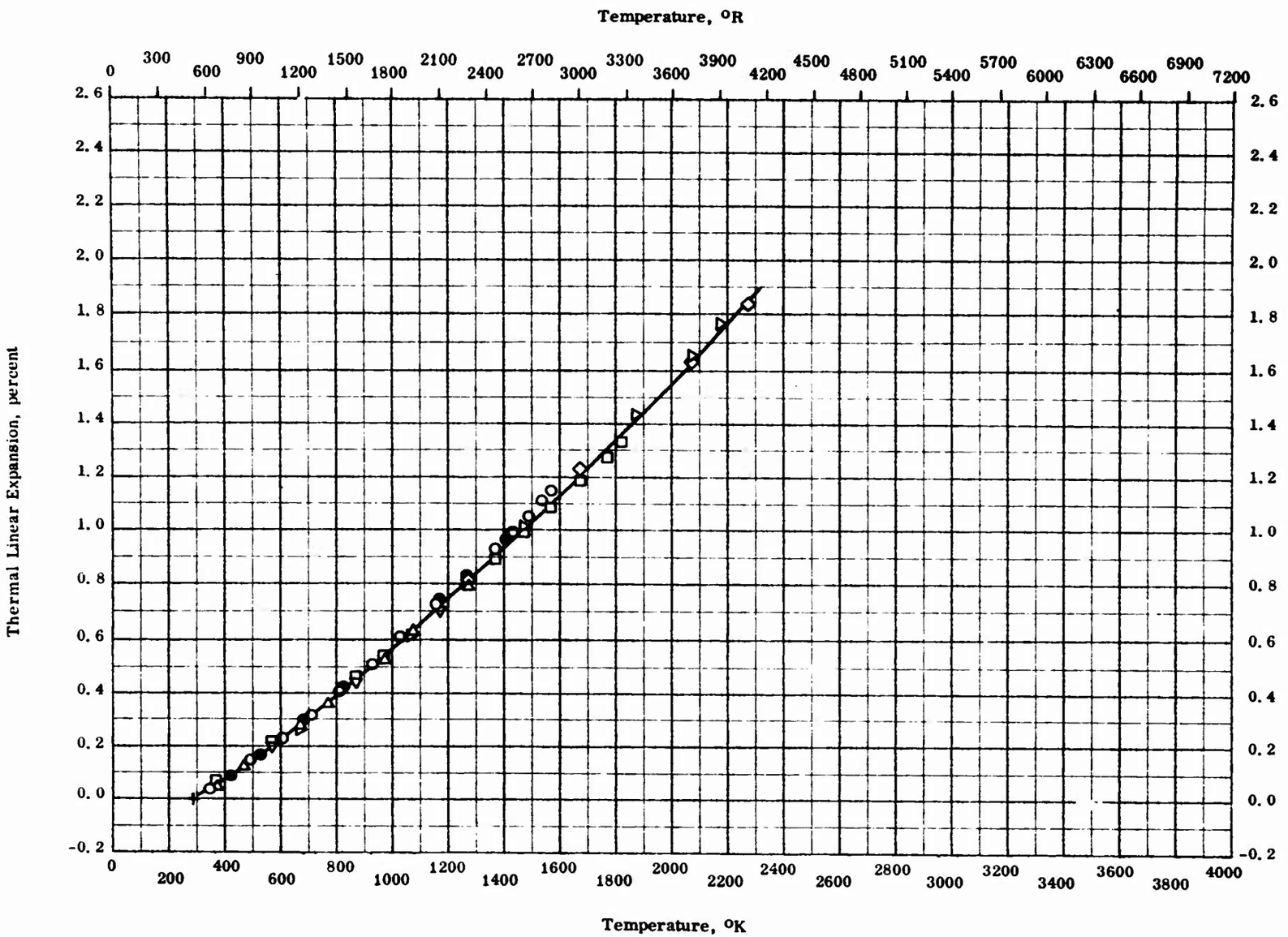


THERMAL CONDUCTIVITY -- YTTRIUM OXIDE

THERMAL CONDUCTIVITY -- YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	64-1	1313-2493		Y_2O_3 powder with total impurities < 0.027; 93.7% of theoretical density after fabrication and 95.8% after measurements.	Cold-pressed at 4000 psi, isostatically pressed at 20,000 psi, sintered for 19 hrs at 1700 C in a H_2 atm, and then machined; data corrected to 100% theoretical density.
○	61-5	367-1367		From Michigan Chem. Co.; 96.3% theoretical density after fabrication.	Dry-pressed followed by isostatic compaction and then sintered at 2950 F in H_2 for 2 hrs.
△	61-5	367-1367		Same as above.	Same as above; data corrected to 100% theoretical density.
●	61-10	346-1438		Y_2O_3; density 4.83 g cm^{-3} (95.8% of theoretical value).	
◆	61-10	373-1473		Same as above.	Data corrected to theoretical density.



THERMAL LINEAR EXPANSION -- YTTRIUM OXIDE

THERMAL LINEAR EXPANSION -- YTTRIUM OXIDE

REFERENCE INFORMATION

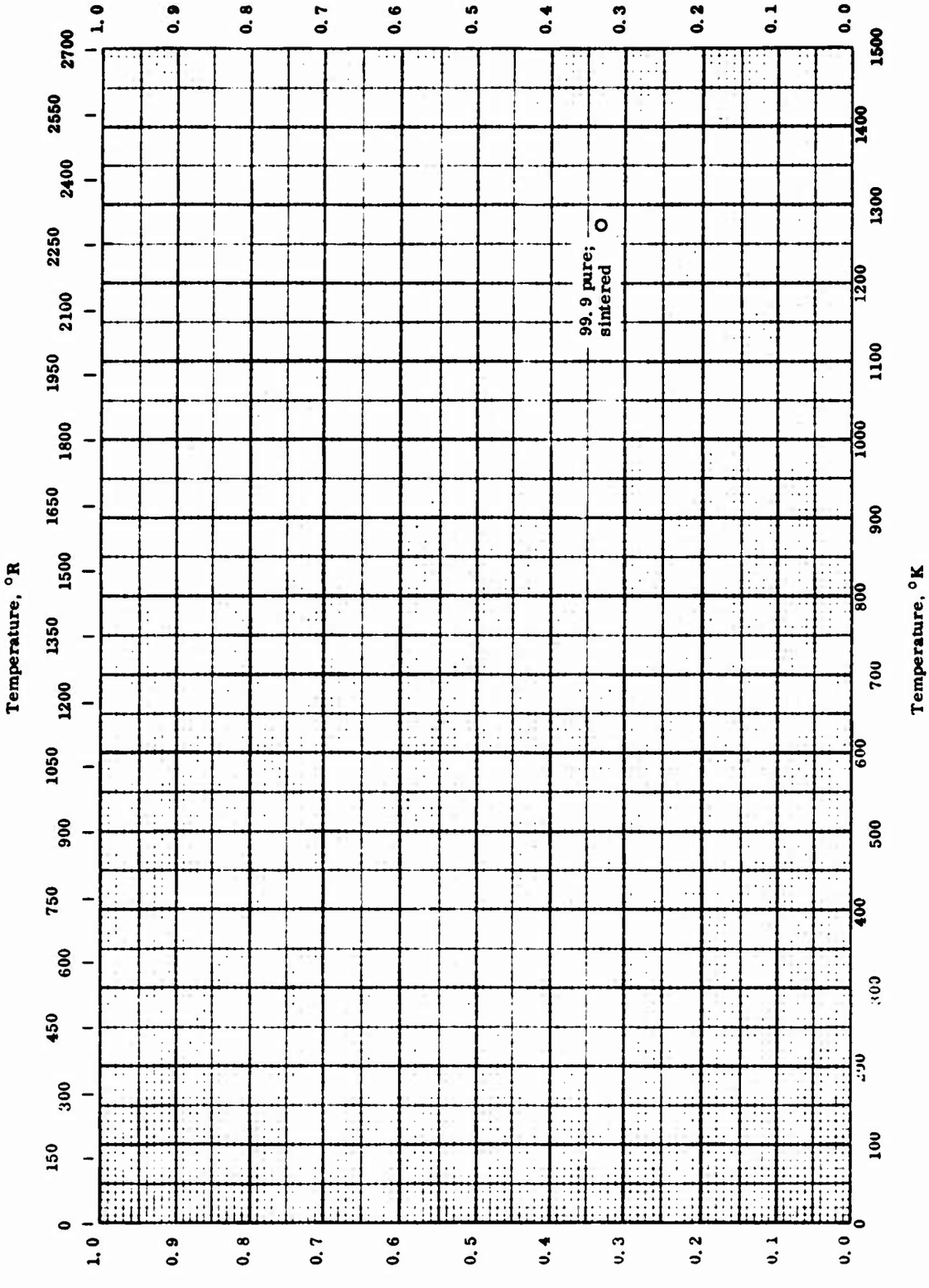
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-41	273-1573	1.1-6.0	Y_2O_3 from Heavy Minerals Co., Chattanooga, Tenn.; 99.9 Y_2O_3 in regard to rare-earth content; 0.003 - 0.03 Si, 0.001 - 0.01 Ca, and trace of Al, Cu, Er, Fe, Mg, and Mn; cubic, rare-earth oxide type C.	Sintered at 1250 C for 24 hrs, packed into alumina sample holder, resintered at 1350 C for 12 hrs, cooled to 150 C, and placed in a vacuum desiccator for storage; x-ray diffractometer method.
●	61-41	421-1573	1.1-6.0	Same as above.	Cooling cycle for above sample.
△	63-35	298-1274		Y_2O_3; 0.003 - 0.03 Ca, 0.001 - 0.01 Al, 0.0003 - 0.003 each Cu, Fe, Mg, Mn, Si, and 0.0001 - 0.001 each Lu, Yb; cubic; bulk density after expansion run by mercury displacement at low pressure 4.2 g cm^{-3}.	Formed from powder by mixing with binder (2 Varsol plus 2 paraffin dissolved in benzene), dry-pressed at 25,000 psi, fired in oxidizing gas furnace to 1800 C for 1 hr, ground into shape, matured to 1000 C for 1 hr, reground, reheated to 1500 C for 1 hr, and placed in a vacuum desiccator; measured with heating rate of 5 C min^{-1}.
▽	63-35	298-1273		Same as above.	Second run for above sample.
□	61-5	298-1823		Michigan Chemical Y_2O_3; dimensions 1/4 in. by 1/4 in. by 2-1/4 in.	Dry pressed, isostatic compacted, and sintered at 2950 F in hydrogen for 2 hrs; measured with temperature raised in steps of 180 F and held 1 hr to allow sample temperature to be uniform.
▷	64-28	298-2173		99.5 - 99.8 Y_2O_3; impurities Fe, Ca, Si, and Al; polycrystalline. [Author's design : LA-15]	Isostatically pressed and sintered at 1700 C in air; measured in 95 oxygen and 5 nitrogen atm; good chemical stability in this environment to 2165 C; permanent expansion occured above 2000 C.

(Continued onto next page)

THERMAL LINEAR EXPANSION -- YTTRIUM OXIDE (continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◇	64-28	298-2273		99.5 - 99.8 Y_2O_3; impurities Fe, Ca, Si, and Al; polycrystalline; weight loss 0.3%.	Isostatically pressed and sintered at 1700 C in air; measured in 80 - 90 argon, 3 - 4 hydrogen, and 6 - 16 air atm; non-identified star-shaped crystals formed a thin surface film which resulted from the reaction between argon-hydrogen atm and the sample surface at some temperature above 1375 C; no change in lattice parameter was found; permanent expansion occured above 2000 C.

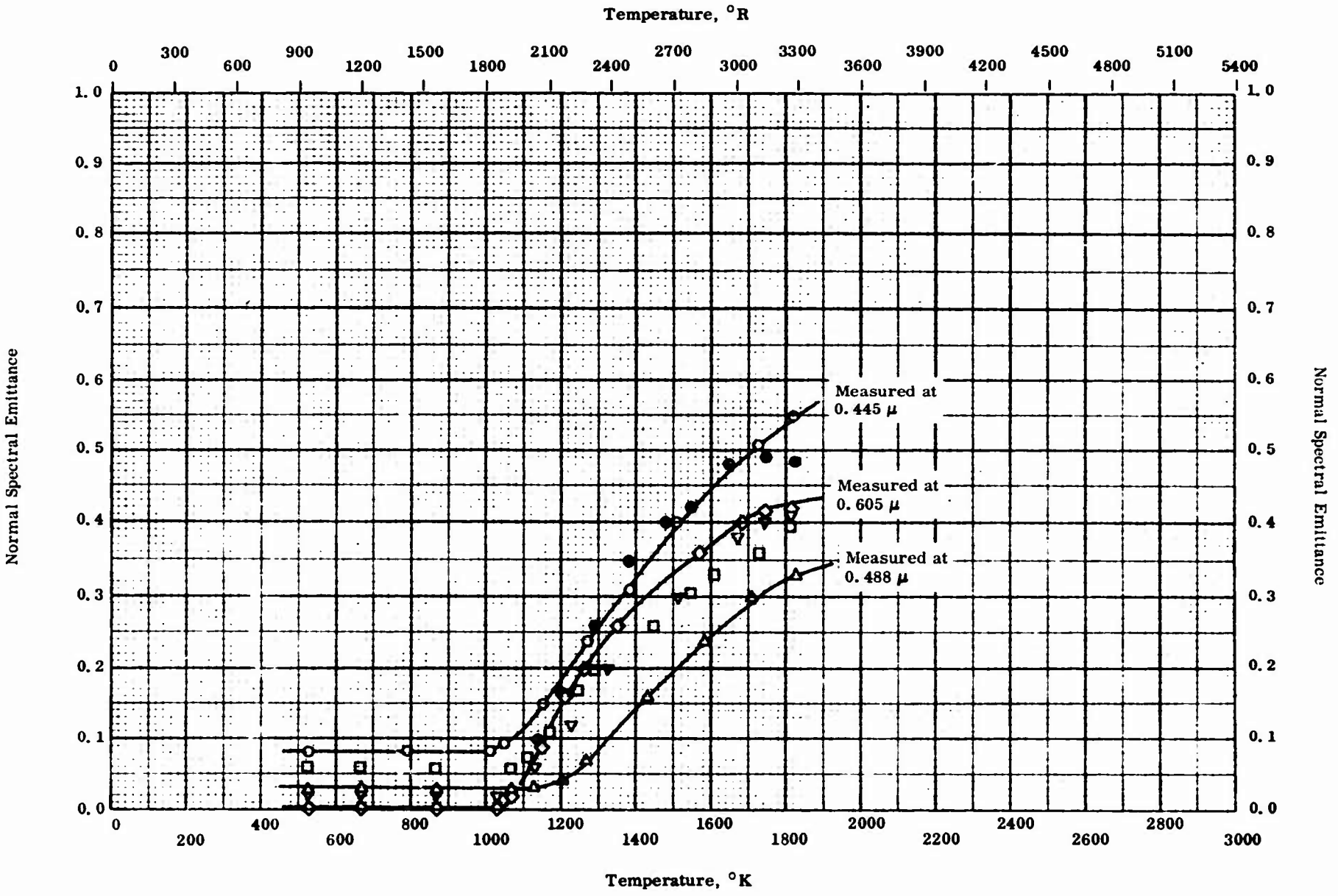


NORMAL TOTAL EMITTANCE -- YTTRIUM OXIDE

NORMAL TOTAL EMITTANCE -- YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	62-23	1273		Y_2O_3, 99.9 pure, 0.033 in. thickness plate.	Sintered at 2023 K for 2 hrs; computed from spectral data.

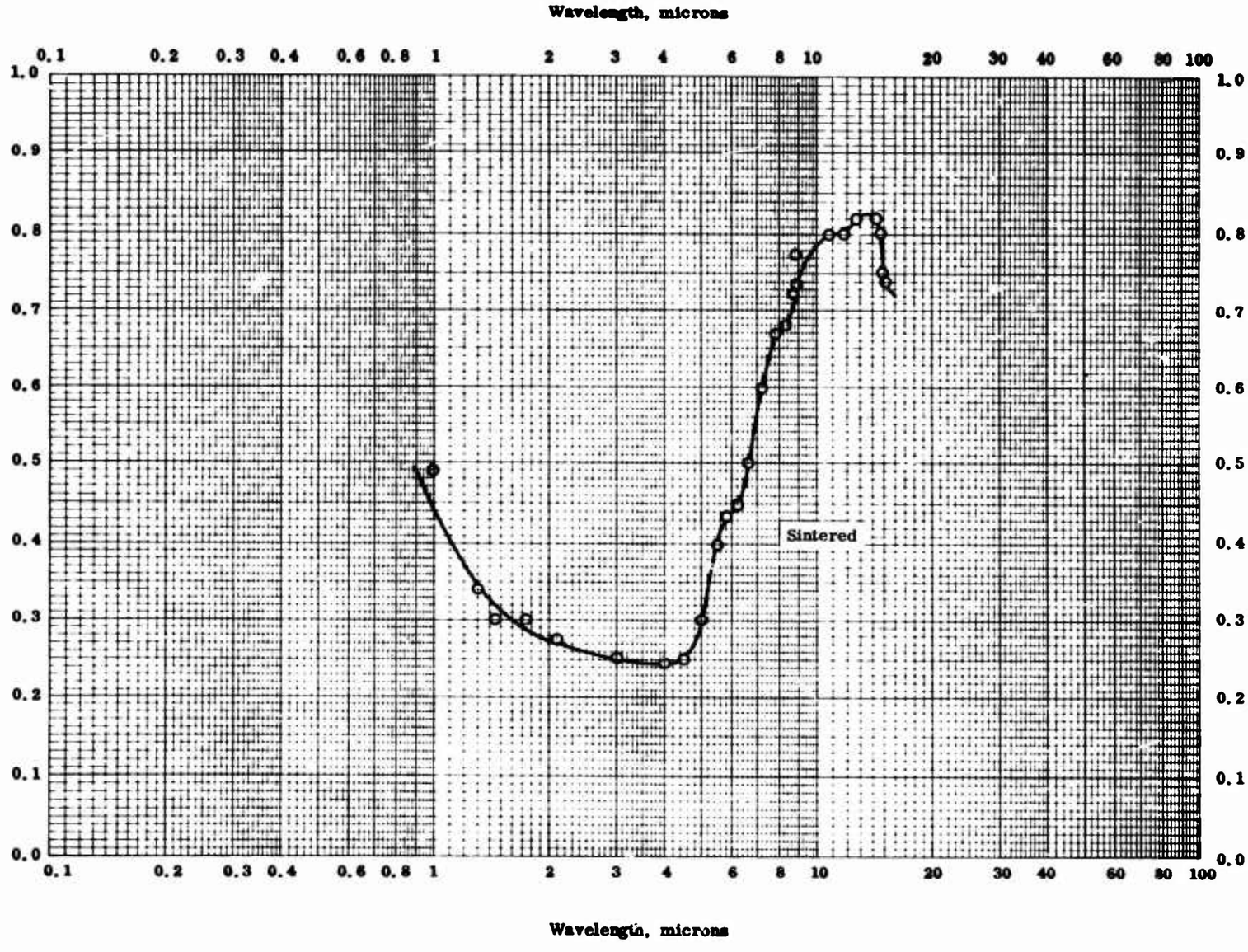


NORMAL SPECTRAL EMITTANCE -- YTTRIUM OXIDE

NORMAL SPECTRAL EMITTANCE -- YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Wavelength μ	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	63-25	0.445	523-1821		Y_2O_3.	Powdered material compressed to 75000 psi, fired at 1773 K for 24 hrs; ground to 0.125 in. thickness; measured in air; calculated from reflectance data; data taken from smooth curve.
△	63-25	0.488	523-1823		Same as above.	Same as above.
□	63-25	0.523	523-1813		Same as above.	Same as above.
▽	63-25	0.570	523-1818		Same as above.	Same as above.
◇	63-25	0.605	523-1813		Same as above.	Same as above.
●	63-25	0.680	523-1823		Same as above.	Same as above.

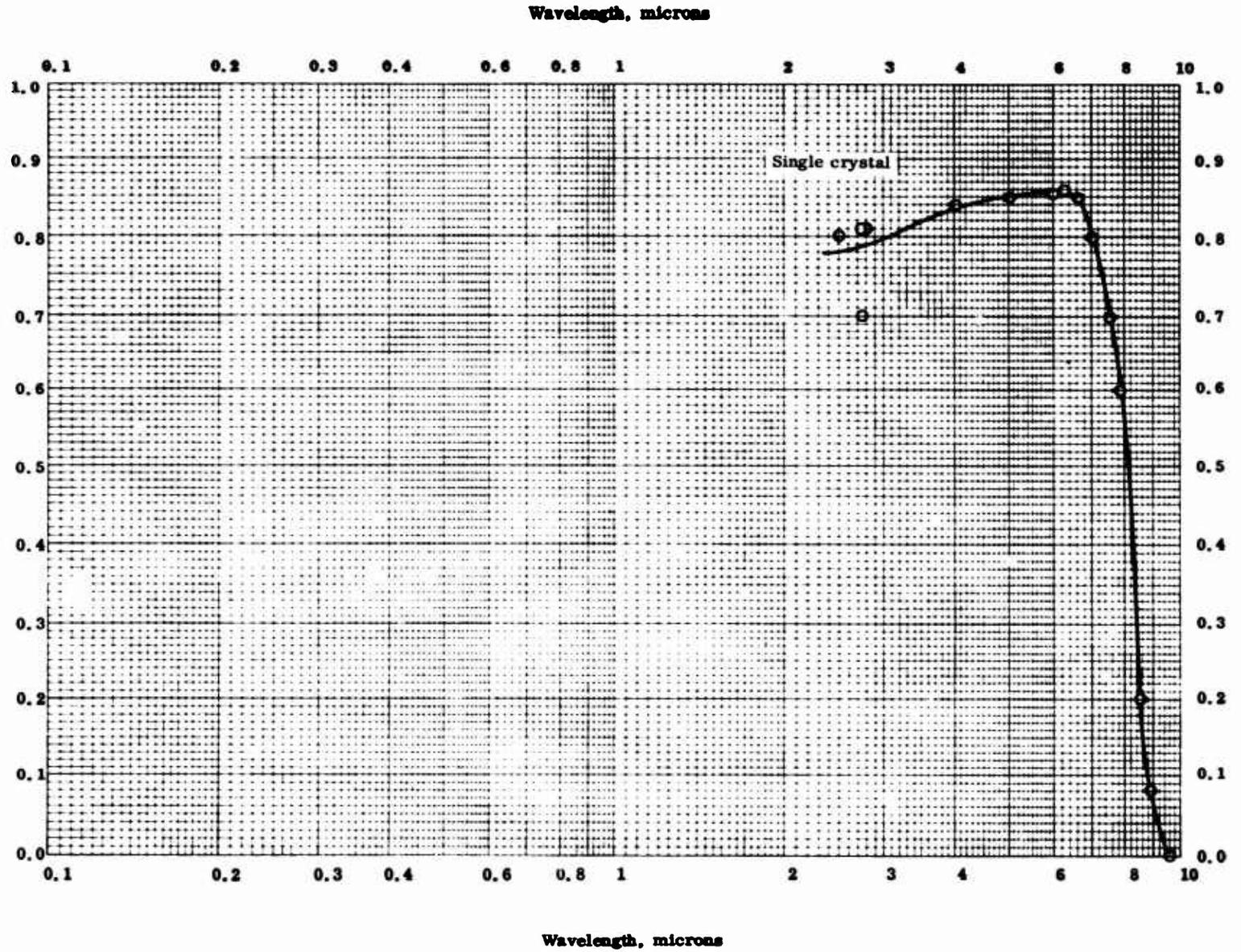


NORMAL SPECTRAL EMITTANCE -- YTTRIUM OXIDE

NORMAL SPECTRAL EMITTANCE -- YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
O	62-23	1273	1 - 15	< 8.9	Y_2O_3. 99.9 pure; 0.033 in. thickness plate.	Sintered at 2023 K for 2 hrs; data taken from smooth curve.

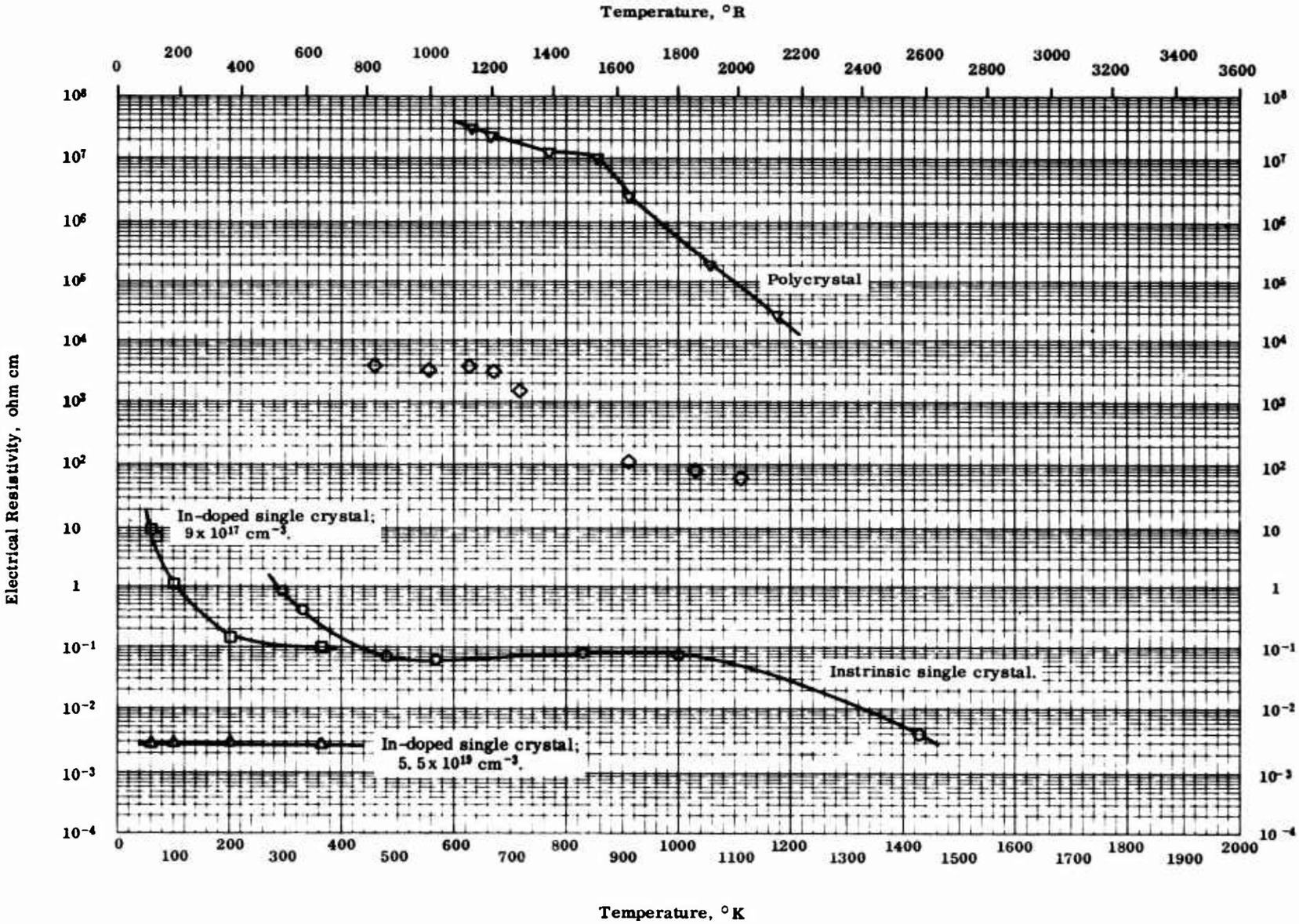


NORMAL SPECTRAL TRANSMITTANCE -- YTTRIUM OXIDE

NORMAL SPECTRAL TRANSMITTANCE -- YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
O	61-31	298	2.5 - 9.6		Y_2O_3, single crystal.	Normalized to 80% transmittance at 2.5μ.

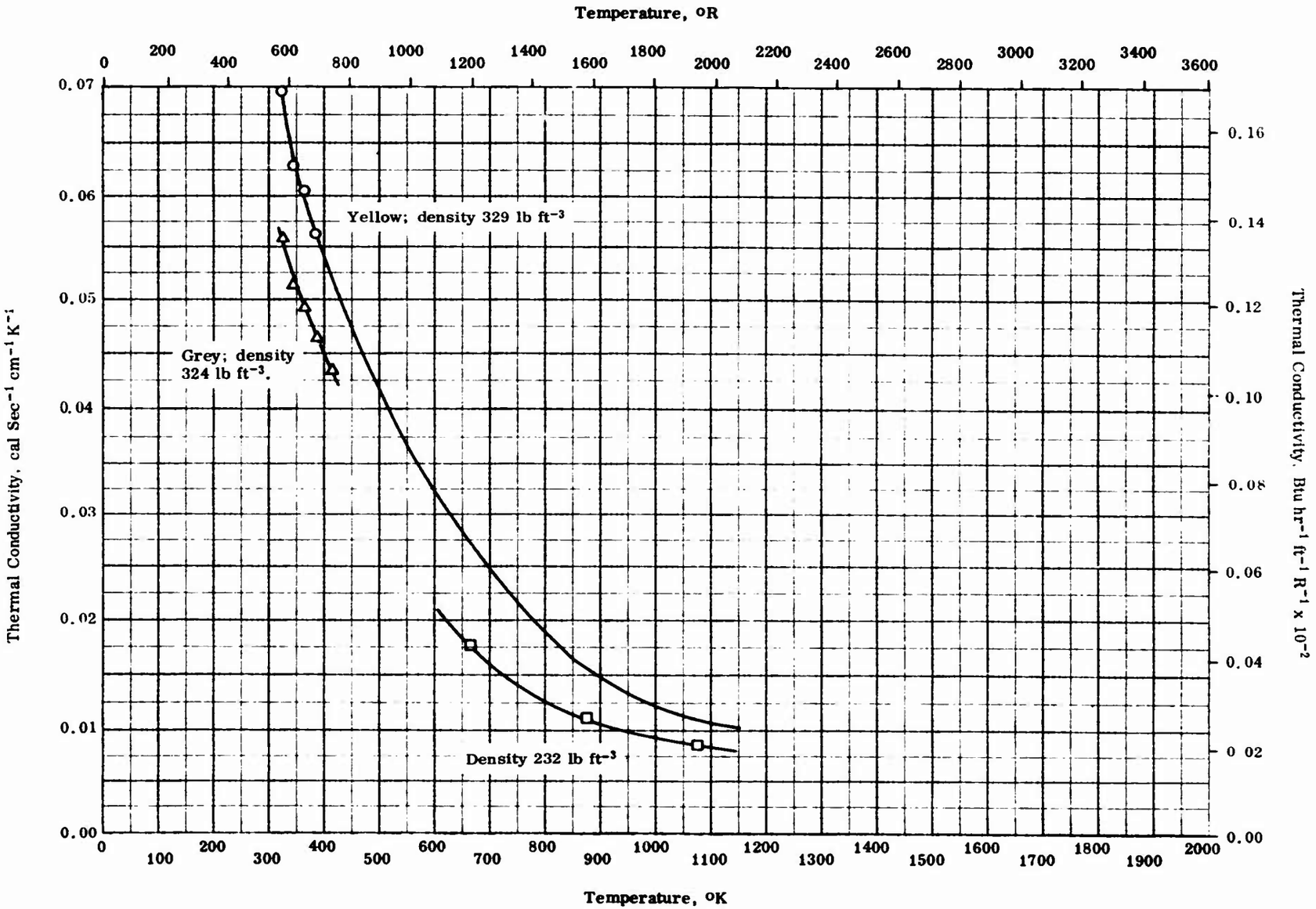


ELECTRICAL RESISTIVITY -- ZINC OXIDE

ELECTRICAL RESISTIVITY -- ZINC OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	56-19	294-1429		ZnO; intrinsic single crystal.	
□	61-24	60-364		In-doped ZnO single crystal, 9×10^{17} cm^{-3}.	
△	61-24	60-364		Same as above except 5.5×10^{19} cm^{-3}.	
▽	56-13	628-1178		Polycrystal ZnO formed from chemically pure materials.	Baked and calcined 2 hrs at constant temperature in furnace; measured under 10^{-5} mm Hg at constant current.
◇	41-4	476-1111		ZnO.	Values unstable, depend on past history of sample.



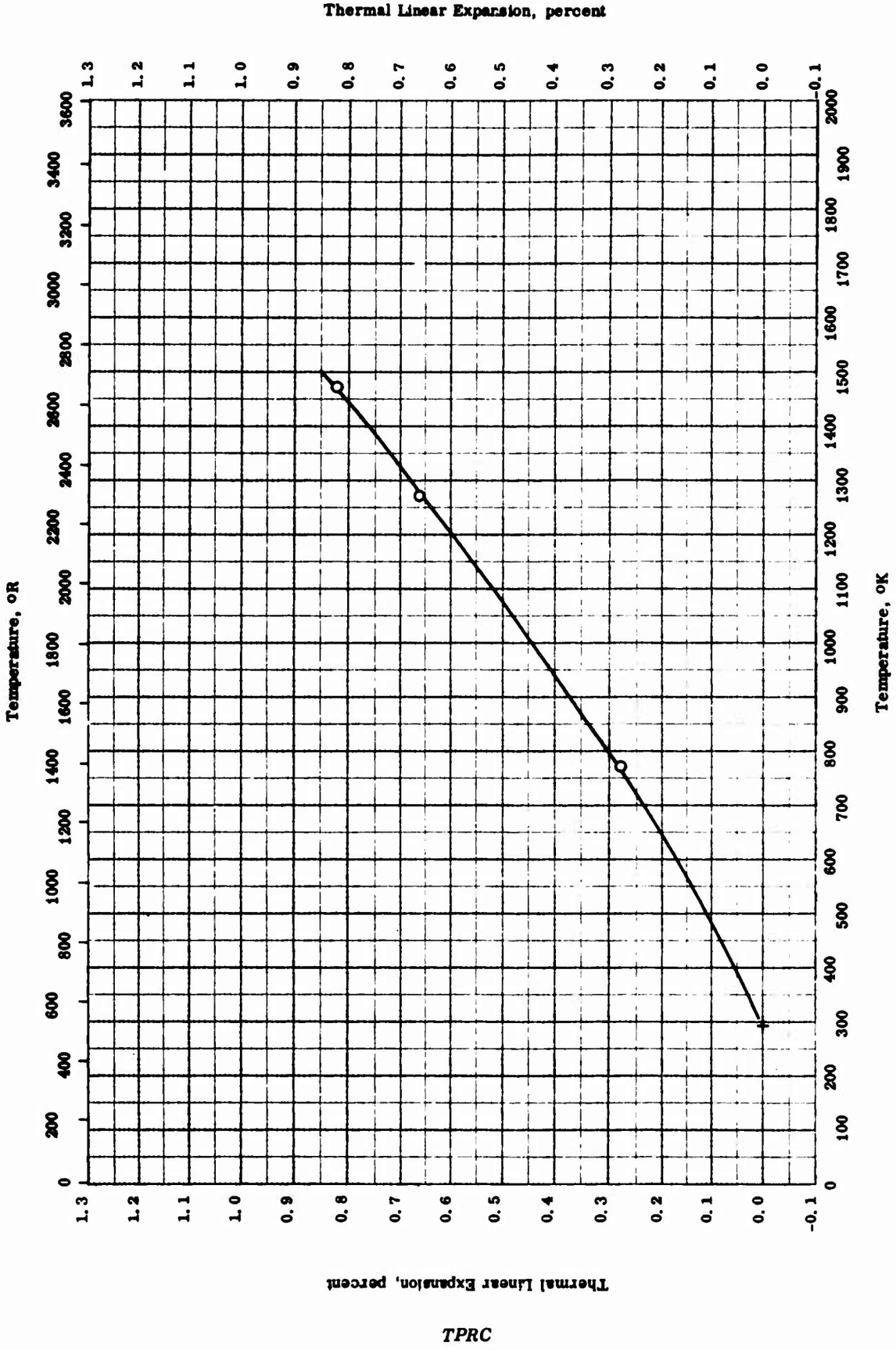
THERMAL CONDUCTIVITY -- ZINC OXIDE

THERMAL CONDUCTIVITY -- ZINC OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-6	320-382		ZnO; yellow; density 330 lb ft^{-3}.	Calcined at 2000 F, dry-pressed at 15000 psi, and fired at 2850 R for 1 hr.
△	53-6	322-413		ZnO; gray, density 325 lb ft^{-3}.	Same as above except fired at 3010 R for 1 hr.
□	54-1	473-1073		ZnO; density 232 lb ft^{-3}, porosity 34%.	Prepared by calcining c.p. ZnO at 900 C and slip casting.

TPRC

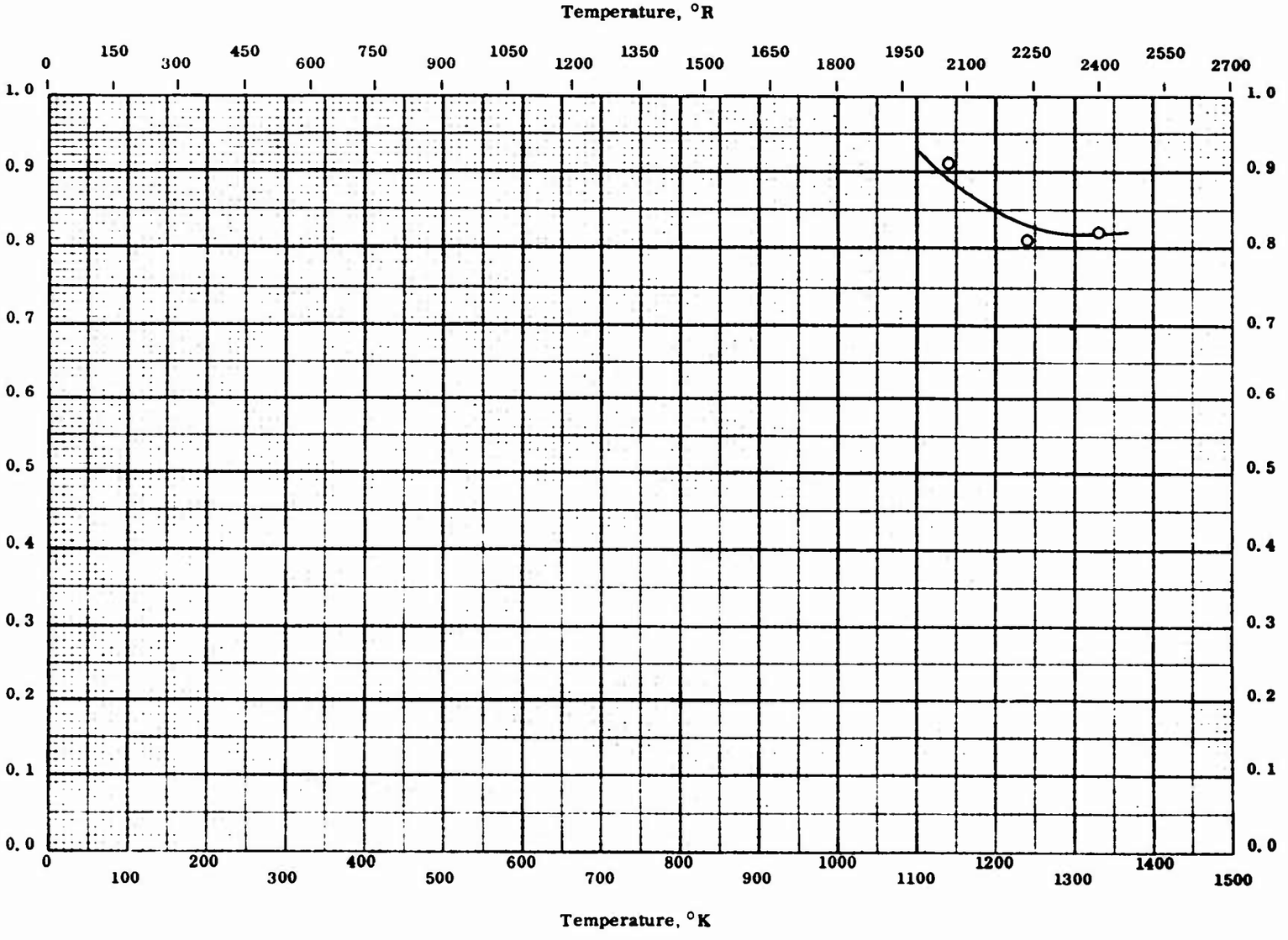


THERMAL LINEAR EXPANSION -- ZINC OXIDE

THERMAL LINEAR EXPANSION -- ZINC OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	60-35	298-1473		ZnO.	



HEMISPHERICAL TOTAL EMITTANCE -- ZINC OXIDE

HEMISPHERICAL TOTAL EMITTANCE -- ZINC OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-28	1140-1330		ZnO crystal.	Measured in vacuum.

PROPERTIES OF ZIRCONIUM DIOXIDE

MOST PROBABLE VALUES

Property	C.G.S. Units	Brit. Eng. Units
Density	5.7	360
Melting Point	2983	5369
Heat of Sublimation . . .	1500_{0K}	2700_{0R}

REPORTED VALUES

Density		$g\,cm^{-3}$	$lb\,ft^{-3}$
	△	5.80	362
	●	5.70	356
	■	3.92	182
	▲	5.4	337

Melting Point		K	R
	□	2822	5080
	◇	3123 ± 25	5532 ± 45
	▼	2973	5352
	◆	2983 ± 10	5369 ± 18
	◁	3118 ± 130	5612 ± 233
	▷	2473	4452
	◐	2950	5310
	◑	~2973	~5352
	⊖	2988	5378

Heat of Sublimation		$cal\,g^{-1}$	$Btu\,lb^{-1}$
	○	$1139_{2150K} \pm 12$	$2050_{3870R} \pm 22$
	▽	1509^{0}_{0K}	2717^{0}_{0R}
	◀	1277^{0}_{0K}	2295^{0}_{0R}

PROPERTIES OF ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

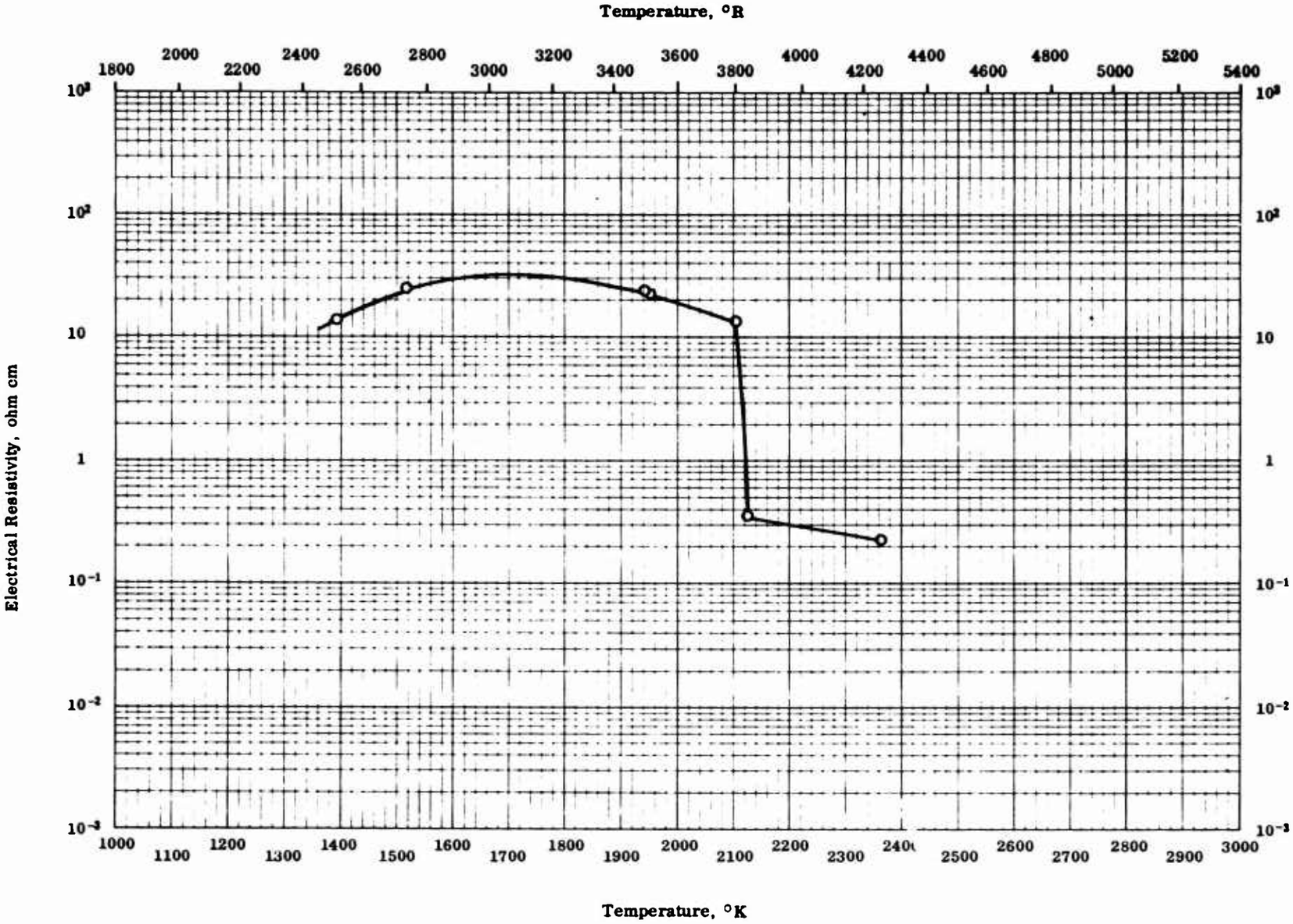
Symbol	Ref.	Temp. Range °K	Rept. Error σ_o	Sample Specifications	Remarks
○	53-8	2150		ZrO_2; by 99.5* Zr with 0.025 > Hf.	Δh_s from vapor pressure data.
□	51-13	2822		Stabilized zirconia.	
△	50-9 also 49-5	298		Stabilized zirconia; 73.44 Zr, 25.43 O_2, 0.16 combined C, and 0.01 free C.	Hot pressed; author quoted theoretical density 6.1 g cm^{-3}; density by weight and in water.
◇	54-18	3073		0.06 Fe, 0.02 Si, 0.015 Al, 0.008 Hf, and 0.006 Ti.	Ground to 325 mesh, pressed at 20,000 psi, and fired 2 hrs at 1600 C.
▽	ND-2	0		ZrO_2.	Δh_s from vapor pressure data.
▼	49-3	2973		ZrO_2.	
◆	53-28	2973-2993		2.0 HfO_2, 0.02 SiO_2, 0.005 each CuO and Fe_2O_3, 0.002 MgO, 0.001 each Al_2O_3 and Na_2O, 0.0005 BaO, 0.0002 Cr_2O_3, and 0.0001 Ba_2O_3.	
◀	54-12	0		ZrO_2 with 0.025 Hf.	$ZrO_2(s) \rightarrow ZrO_2(g)$; author recommended ΔH (k cal $mole^{-1}$) = 157,300-7.80T-400,000 T^{-1} (T in K) and also ΔH dissociation $ZrO_2(g) \rightarrow Zr(g) + O_2(g)$= 368 ± 5 k cal $mole^{-1}$.
◁	50-10	2988-3247		ZrO_2.	M. P. by visual observation.
▷	51-15	2473		ZrO_2.	
●	50-11	298		ZrO_2.	Density computed from x-ray measurement
■	50-11	298		ZrO_2.	Pressed at 52,000 psi.

(Continued onto next page)

TPRC

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▲	50-11	298		ZrO_2.	Fired at 2100-2300 C.
◐	62-20	2950		ZrO_2.	
◑	64-8	2973		ZrO_2.	Structure transformation at 1373 K.
⊖	61-29	2988		ZrO_2.	

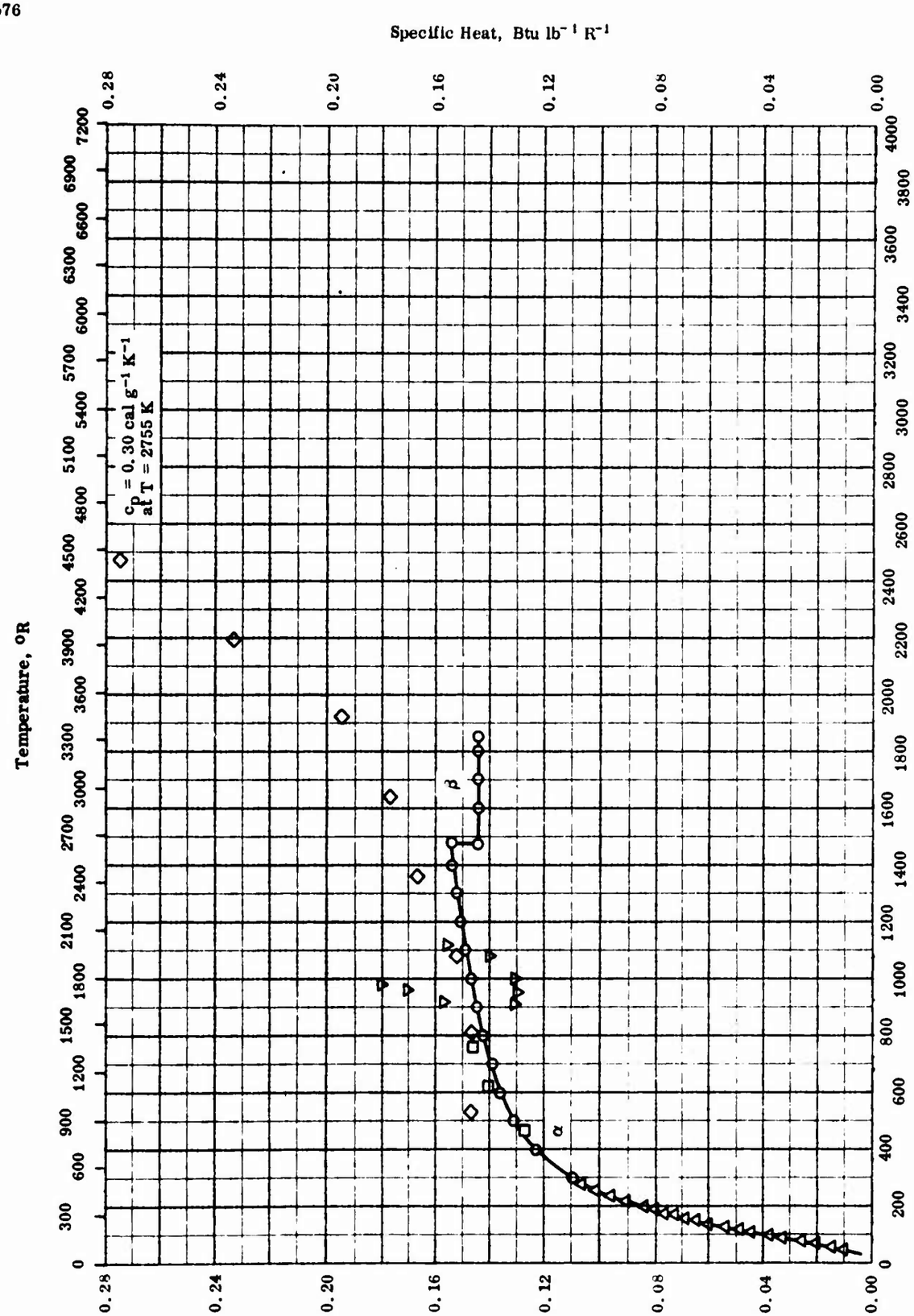


ELECTRICAL RESISTIVITY -- ZIRCONIUM DIOXIDE

ELECTRICAL RESISTIVITY -- ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

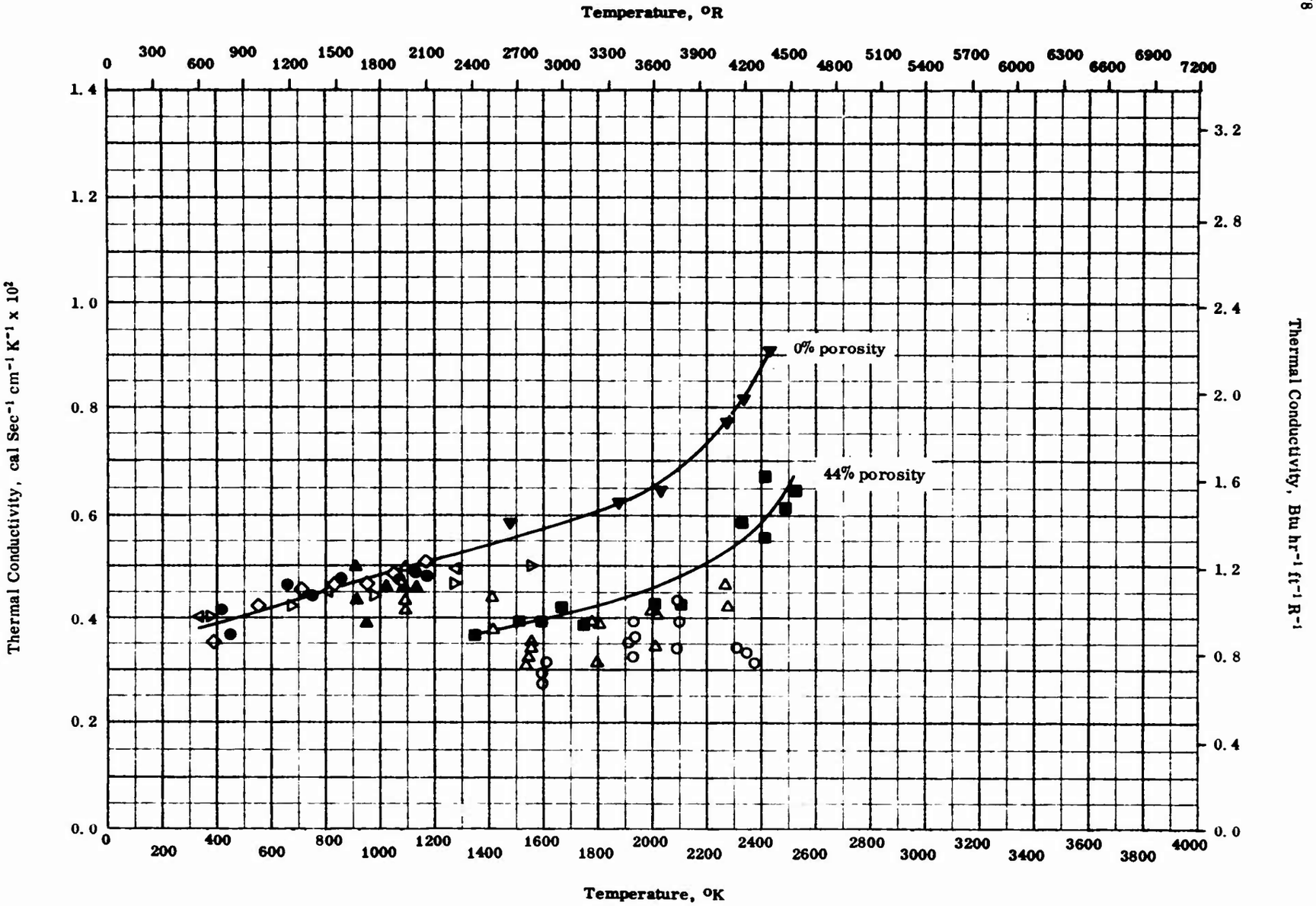
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	62-4	1394-2366	2.4	ZrO_2; 70.7 Zr.	Pressed and sintered; maximum exposure temperature 4600 F.



SPECIFIC HEAT -- ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	50-6	298-1850	0.2	1.25 Hf; X-ray diffraction showed only monoclinic oxide.	
△	44-1	54-295		99.14 ZrO_2, 0.30 SiO_2, 0.20 TiO_2, 0.07 CaO, and 0.05> other oxides.	Corrected for impurities.
□	50-5	296-1266		ZrO_2.	
◇	62-4	533-2755	≤5.0	Before test: 70.7 Zr, 1.0 Ca, 0.1 Al, 0.1 Mg, 0.1 Si, and 0.1 Ti; density 351 lb ft^{-3}; after test: 71.2 Zr, and 0.15 C; density 357 lb ft^{-3}.	
▽	61-3	836-1127		Sample A, B, C density 271 lb ft^{-3} and sample D density density 342 lb ft^{-3}.	



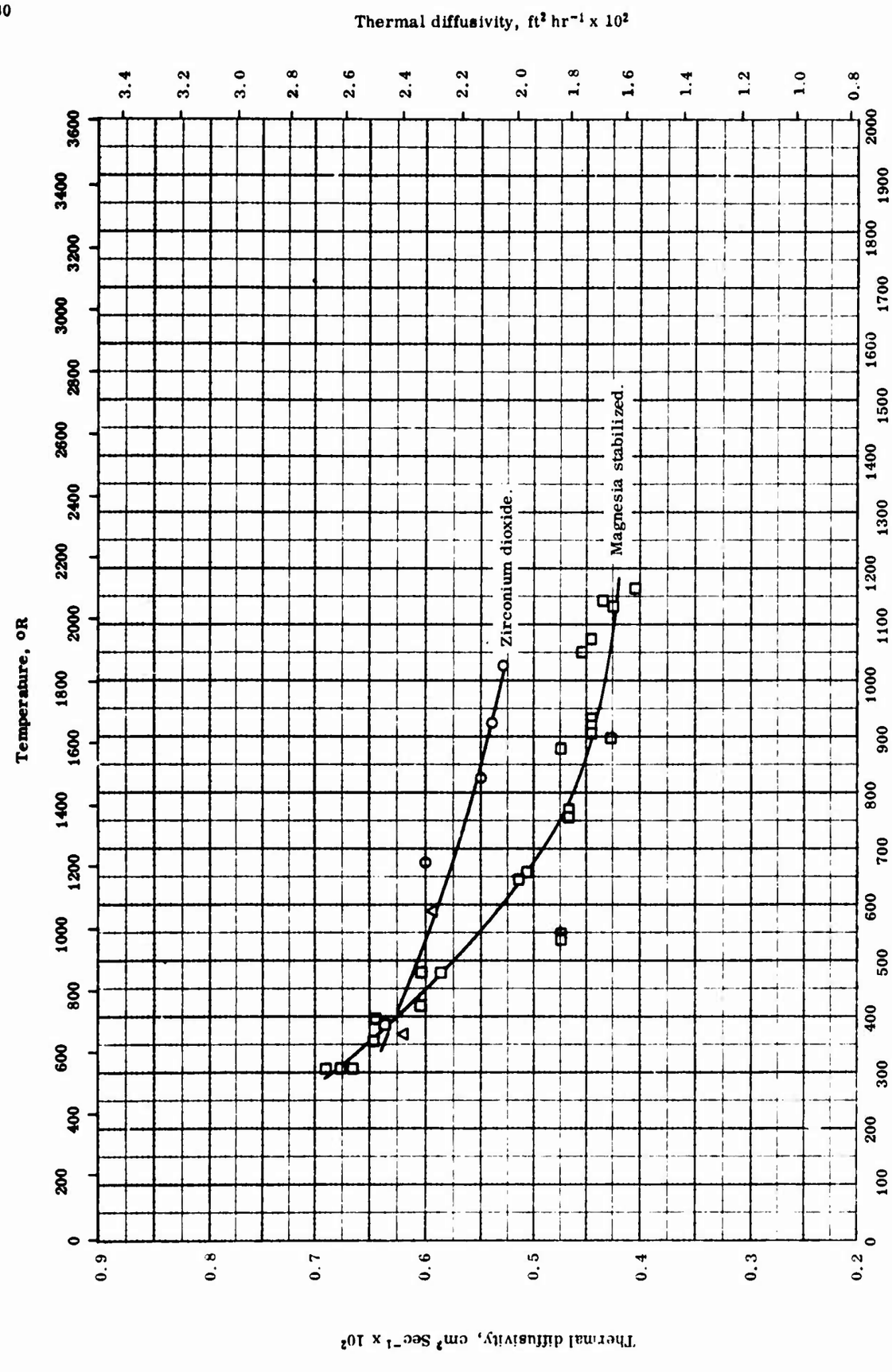
THERMAL CONDUCTIVITY -- ZIRCONIUM DIOXIDE

TPRC

THERMAL CONDUCTIVITY -- ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▷	54-6	373-1573		Density 326-334 lb ft^{-3} and porosity 7.76 - 10.0%.	Slip cast from suspension of finely ground material.
◇	51-2	389-1168		Density 334 lb ft^{-3} and total porosity 2.37%.	Stabilized.
●	51-2	389-1168		Density 326 lb ft^{-3} and total porosity 4.74%.	Stabilized.
◁	51-3	345-1278			Stabilized.
△	62-4	1089-2281	5-7		Ground and polished thoroughly; sample broken on post inspection.
○	62-4	1592-2374	5-7		Same as above; sample found cracked with discoloration on post inspection.
▲	61-3	907-1127	4.5	Density 5.48 g cm^{-3}.	Cut from a ZrO_2 cylinder; 0.001 in. silver foil placed on both surfaces before assembling.
■	64-1	1343-2523		Density 4.046 g cm^{-3} (66.3% of theoretical).	CaO stabilized ZrO_2.
▼	64-1	1473-2423		Same as above.	Same as above; data corrected to 100% theoretical density.

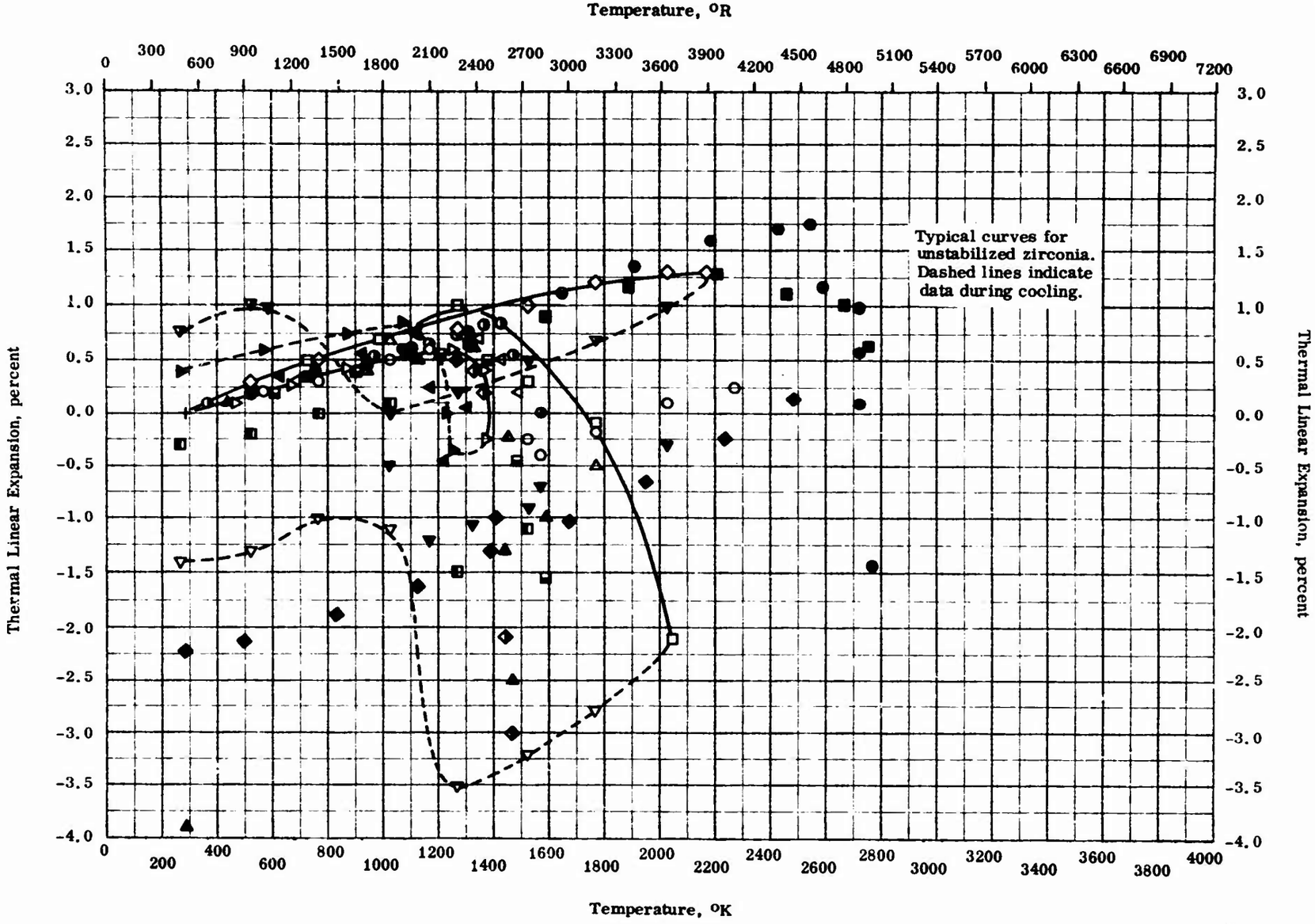


THERMAL DIFFUSIVITY -- ZIRCONIUM DIOXIDE

THERMAL DIFFUSIVITY -- ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	50-1	673-1023		True density 5.6 g cm^{-3}; 0.1% open pores and 5.4% total porosity.	Cast from acid suspensions of fine ground material and fired 1800 C for 5 hrs.
□	63-1	303-1163	±5	Norton mix 302; high purity.	Magnesia stabilized.
△	61-1	367-589		Zirconia.	



THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

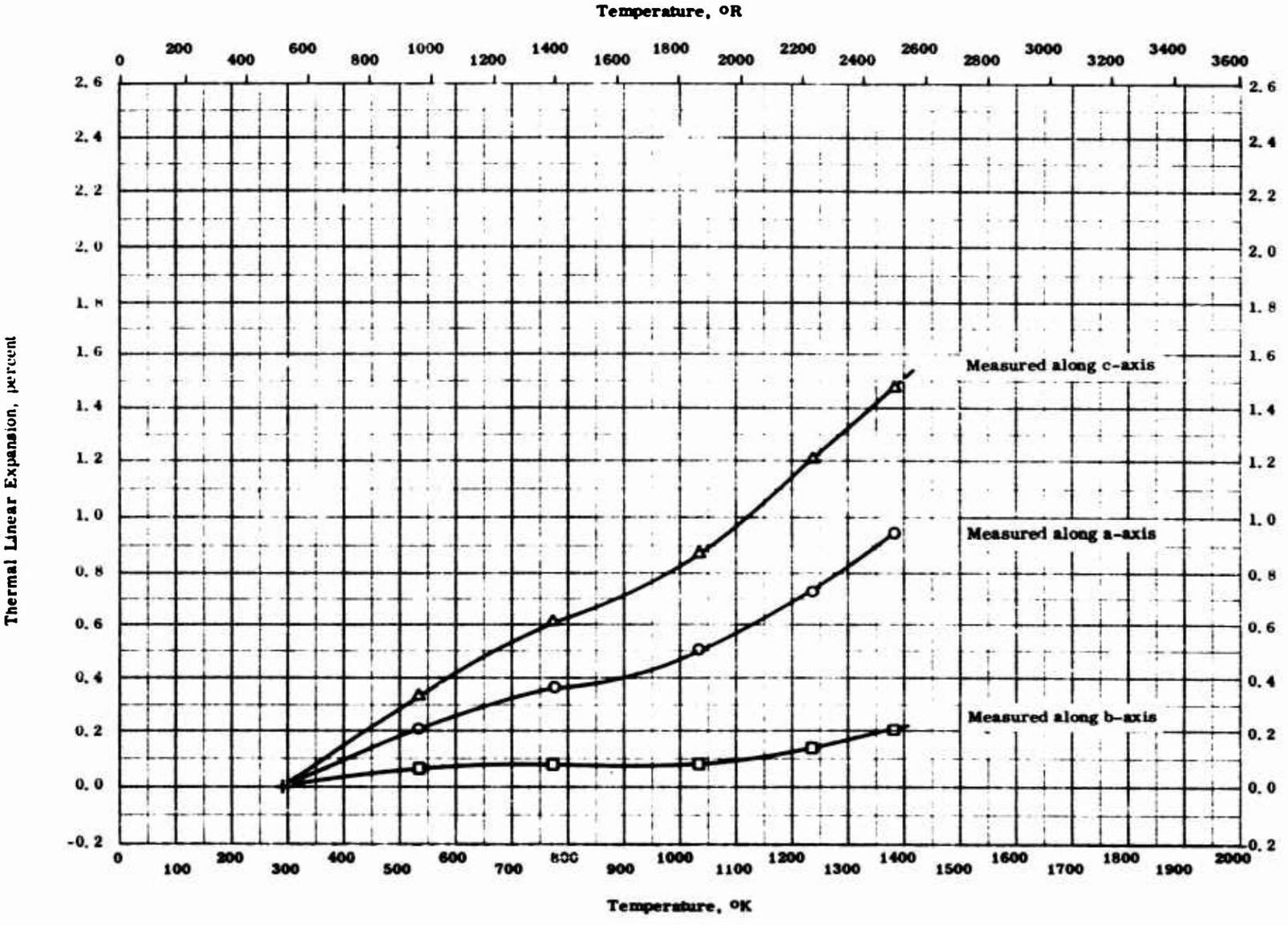
Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
●	62-4	294-2772	5	ZrO_2 from Zirconium Corp. of Am.; 70.7 Zr; elements found by semi-quantitative emission spectrography before exposure 1.0 Ca, 0.1 Si, 0.1 Mg, 0.1 Ti, and 0.1 Al; after exposure 71.2 Zr and 0.15 C; density in g cm^{-3} at 25 C by ASTM method B311-58 before exposure 5.36, after exposure 5.35; initial length 3.020 in., final length 2.942 in. [Author's design: Run No. E 12]	Pressed and sintered; measured in helium atm.
▲	62-4	294-2772	5	Same as above.	Cooling cycle for above sample.
■	62-4	294-2758	5	Same as above; initial length 3.001 in., final length 2.956 in. [Author's design: Run No. E 19]	Same as heating cycle for above sample.
◆	62-4	294-2758	5	Same as above.	Cooling cycle for above sample.
○	49-9	273-2273		ZrO_2 with approx 1 HfO_2; density 337 lb ft^{-3}.	Fired at 1400 C, molded under pressure, and heated 15 min at 2200 C in air stream.
▼	49-9	593-2023		Same as above.	Cooling cycle for above sample.
□	49-9	273-2023		99 ZrO_2 and 1 BeO of 99 purity; density 305 lb ft^{-3}.	Precipitated from solution, washed, dried, compression molded, and baked at 2200 C.
▽	49-9	273-1523		Same as above.	Cooling cycle for above sample.
△	49-9	273-1773		Same as above.	Same as heating cycle for above sample.
◧	49-9	273-1523		Same as above.	Cooling cycle for above sample.

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THERMAL LINEAR EXPANSION -- ZIRCONIUM OXIDE (Continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◇	49-9	273-2173		Pure ZrO_2; density 341 lb ft^{-3}.	Melted in arc furnace, cast, finely broken, molded under pressure, and heated 15 min at 2100 C in air.
▽	49-9	273-2023		Same as above.	Cooling cycle for above sample.
◑	54-18	373-1573		ZrO_2; 0.06 Fe, 0.02 Si, 0.015 Al, 0.008 Hf, and 0.006 Ti.	Ground to pass 325 mesh screen, pressed at 20,000 psi with 5% water and 2% dextrin, and fired in oxyacetylene furnace 2 hrs at 1600 C.
▷	56-11	293-1373		99.6 ZrO_2, 0.2 SiO_2, and trace of Al_2O_3, Fe_2O_3, and TiO_2; density 362 lb ft^{-3}.	Calcined 2 hrs at 1600 C, ground to 250 mesh, dry pressed (1 ton cm^{-2}), and fired 2 hrs at 1600 C.
▶	56-11	273-1373		Same as above.	Cooling cycle for above sample.
◁	54-37	293-1493		99 ZrO_2, Grade A Zirox of National Lead Co.	Heating cycle.
◀	54-37	633-1303		Same as above.	Cooling cycle for above sample.
▲	52-3	288-1473		ZrO_2.	Heated 3 hrs at 1000 C.
▲	52-3	288-1593		Same as above.	Heated 3 hrs at 1150 C.
◆	52-3	288-1473		99.51 ZrO_2 and 0.49 SiO_2.	Heated 3 hrs at 1000 C.
■	52-3	288-1593		Same as above.	Heated 3 hrs at 1150 C.

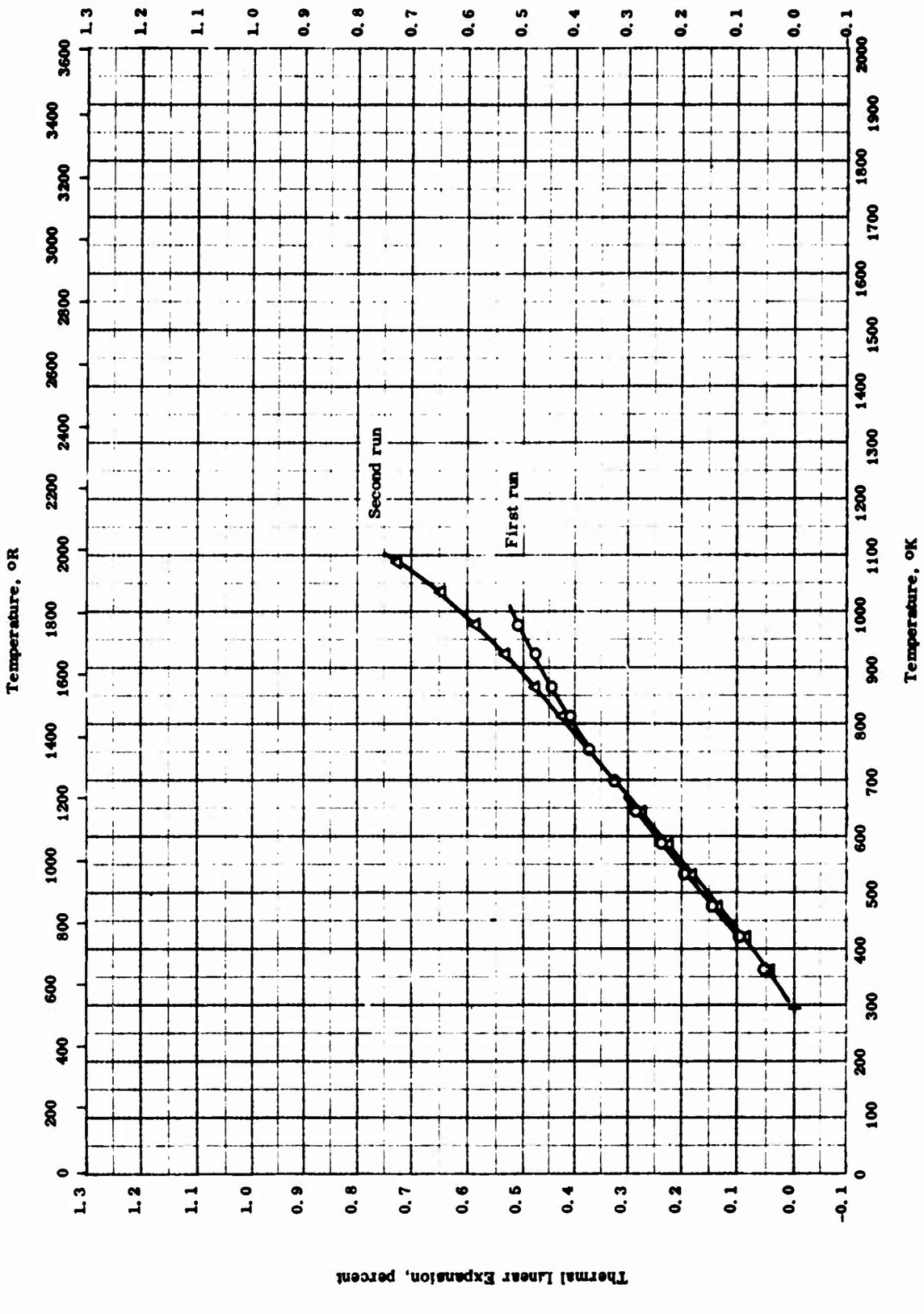


THERMAL LINEAR EXPANSION - - ZIRCONIUM DIOXIDE
(Baddeleyite)

THERMAL LINEAR EXPANSION — ZIRCONIUM DIOXIDE
(Baddeleyite)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-28	300-1389	2-3	99.9 ZrO_2 (baddeleyite), 0.3 - 3 Hf, 0.003 - 0.03 each Al, Mg, 0.001-0.01 each Ca, Cu, Fe, Si, Ti, and trace of B, Cr, and Mn; monoclinic.	Mixture of ZrO_2 with approx 40 Pt powder fired at 1000 C for 24 hrs; Pt powder used for furnace alinement and thermal calibration; measured along a-axis with x-ray diffractometer.
□	62-28	300-1383	2-3	Same as above.	Same as above except measured along b-axis.
△	62-28	300-1383	2-3	Same as above.	Same as above except measured along c-axis.



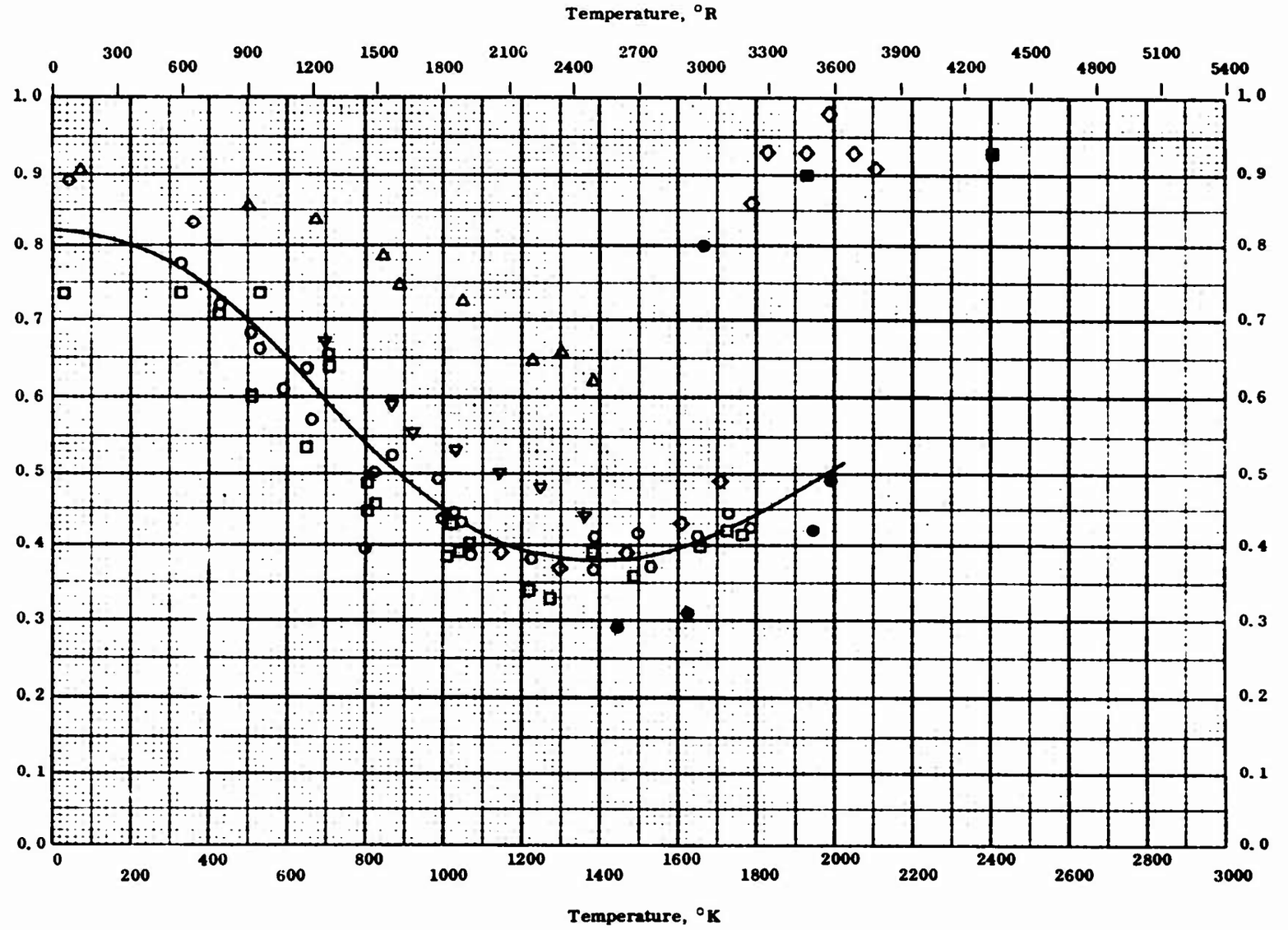
THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE FOAM

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE FOAM

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	62-30	293-978		30 - 35 -100 mesh ZrO_2, 20 - 25 -325 mesh ZrO_2, 20 - 25 of 90 rare-earth oxide, 10 - 12 H_3PO_4, 10 - 12 H_2O, 1 - 2 carbon powder, and 0.05 - 0.1 Al powder; density 100 lb ft^{-3}; dimensions 2 in. long by 1/4 in. square.	Cured at 200 F; temperature raised to 600 F over 20 hr period and held at 600 F for 24 hrs; reference temperature not given, assumed to be 68 F.
△	62-30	293-1089		Same as above.	Second run for above sample.

TPRC

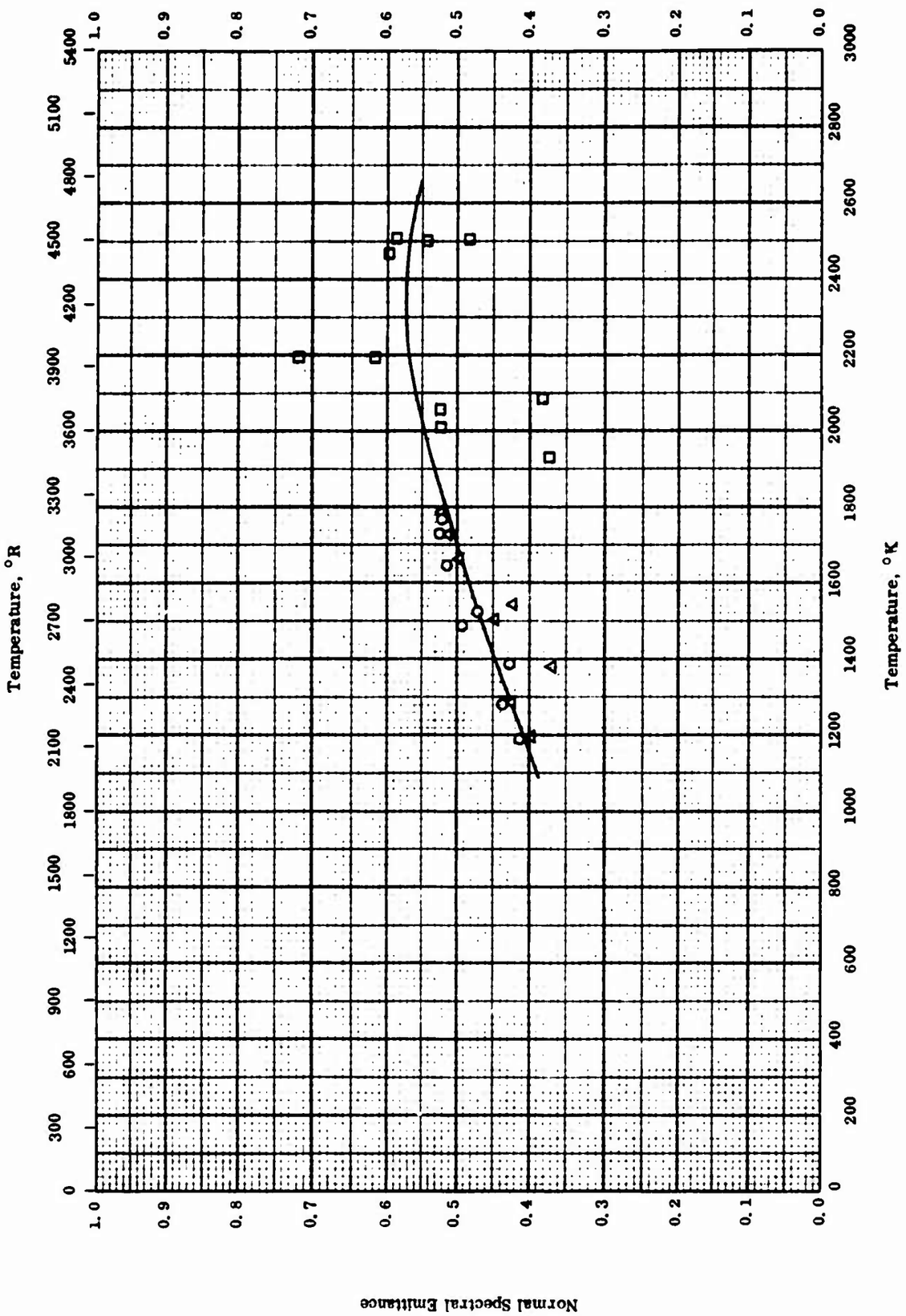


NORMAL TOTAL EMITTANCE -- ZIRCONIUM DIOXIDE

NORMAL TOTAL EMITTANCE -- ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	59-15	44-1783		ZrO_2.	Calcium stabilized; measured in air.
□	59-15	39-1778		ZrO_2.	Magnesium stabilized; same as above.
△	59-15	78-1583		ZrO_2, coating on Inconel.	Measured in air.
▽	59-13	700-1366		ZrO_2, coating flame-sprayed on sandblasted and oxidized Inconel strip.	
◇	62-4	1152-2103	10	ZrO_2; density 5.63 g cm^{-3}.	Pressed and sintered; measured in dry argon atmosphere; run No. 1.
■	62-4	1938-2908	10	Same as above.	Same as above; run No. 2.
●	62-4	1443-1998	10	Same as above.	Air jets directed to surface of specimen; run No. 3.

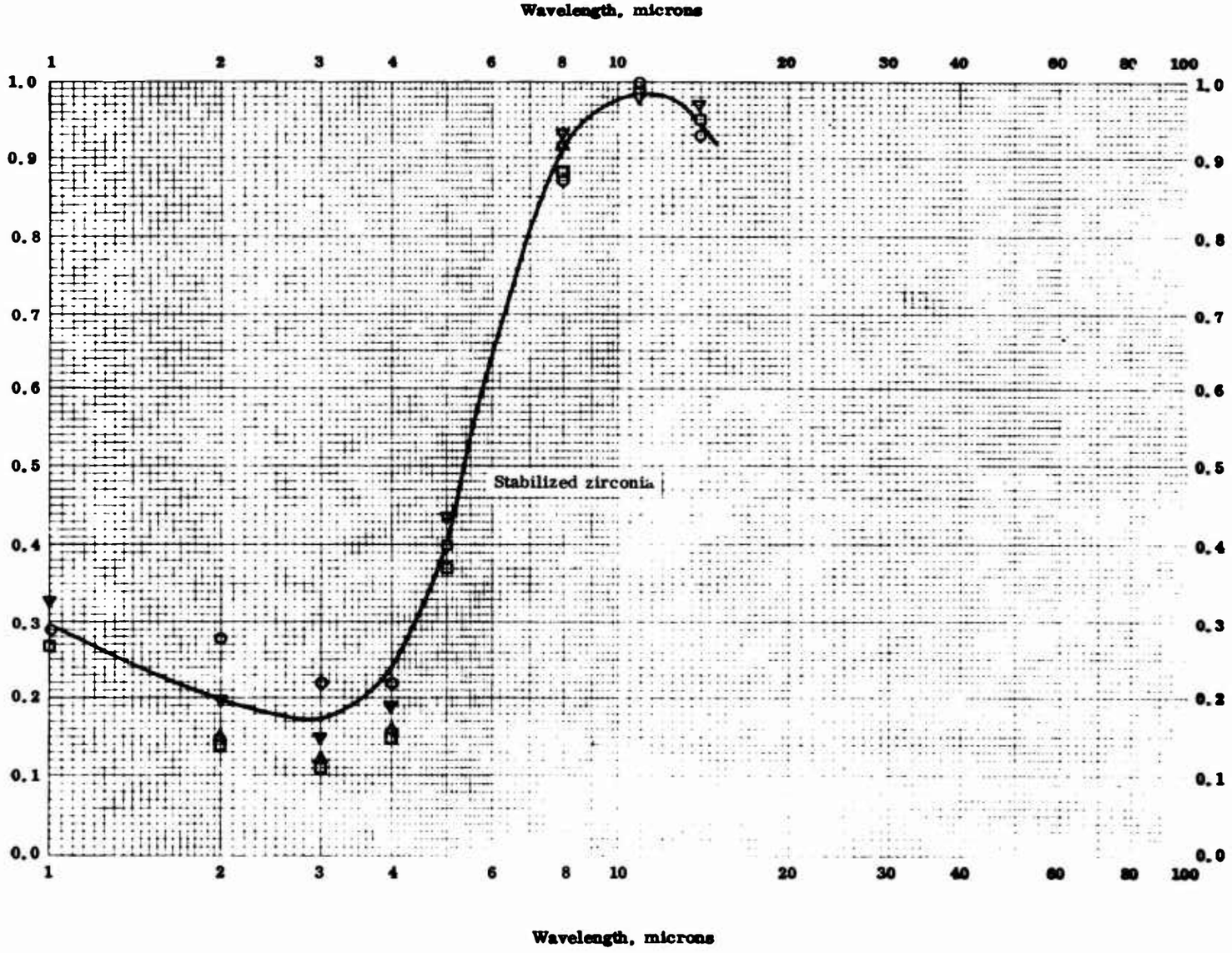


NORMAL SPECTRAL EMITTANCE -- ZIRCONIUM DIOXIDE

NORMAL SPECTRAL EMITTANCE -- ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Wavelength μ	Temp. Range, °K	Rept. Error%	Sample Specifications	Remarks
○	59-15	0.665	1194-1778		ZrO_2.	Calcium stabilized.
△	59-15	0.665	1200-1783		ZrO_2.	Magnesium stabilized.
□	62-25	0.69	1939-2516		ZrO_2.	Uncoated material ground to a smooth finish; measured in dry argon or helium atmosphere after evacuation to 2 mm Hg.



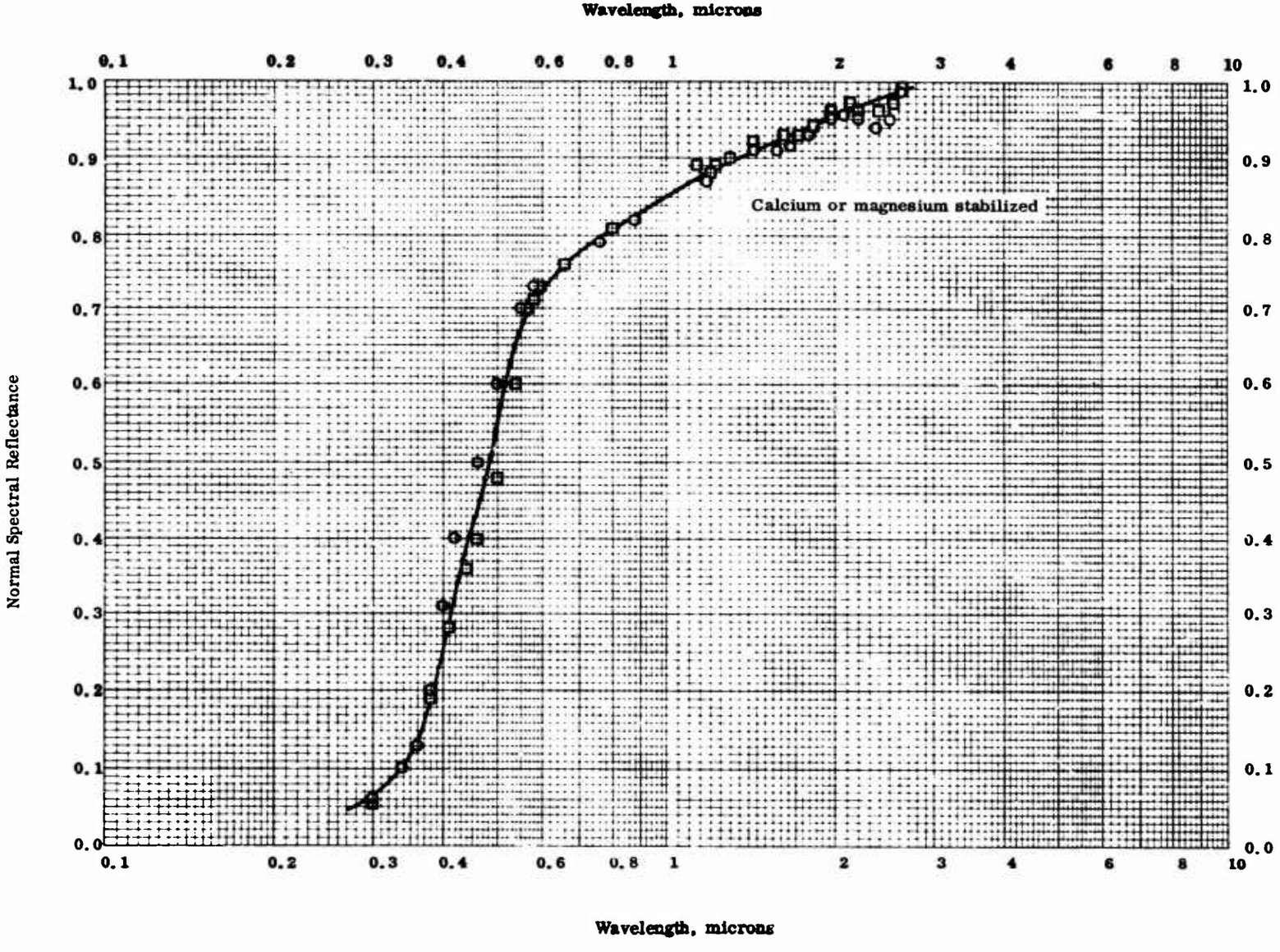
NORMAL SPECTRAL EMITTANCE -- ZIRCONIUM DIOXIDE

NORMAL SPECTRAL EMITTANCE -- ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
○	64-12	867	1-14	±5	ZrO_2 from Norton Co.; stabilized zirconia-H.	Grinding, leaching, and slip casting, fired at 2023 K.
□	64-12	1048	1-14	±5	Same as above.	Same as above.
△	64-12	1183	1-14	±5	Same as above.	Same as above.
▽	64-12	1298	1-14	±5	Same as above.	Same as above.

TPRC

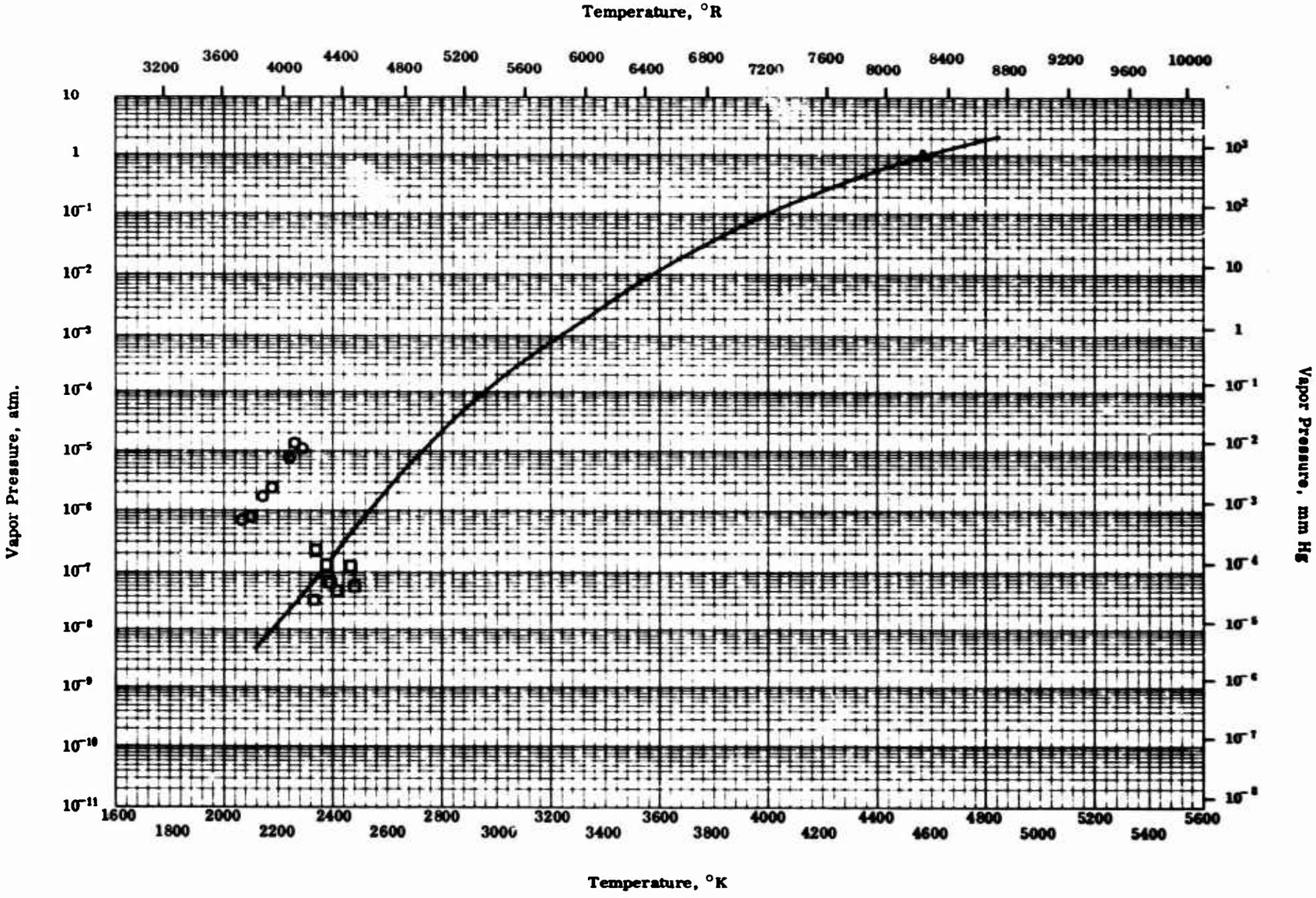


NORMAL SPECTRAL REFLECTANCE -- ZIRCONIUM DIOXIDE

NORMAL SPECTRAL REFLECTANCE -- ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
O	59-15	298	0.3-2.61	4	ZrO_2.	Calcium stabilized; data taken from smooth curve; 6-9 degree illumination, hemispherical viewing; $MgCO_3$ as reference standard.
□	59-15	298	0.3-2.62	4	ZrO_2.	Magnesium stabilized; same as above.

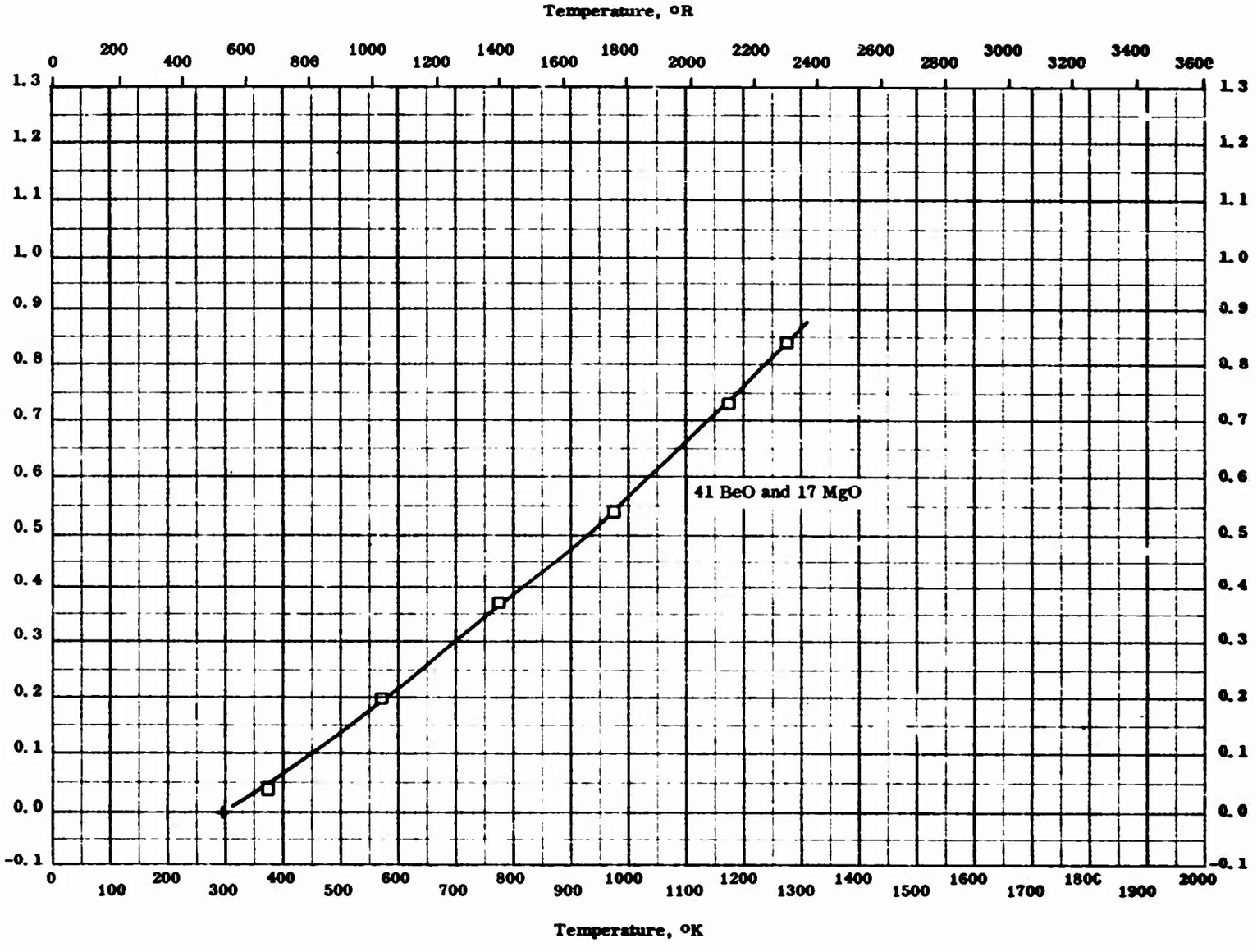


VAPOR PRESSURE -- ZIRCONIUM DIOXIDE

VAPOR PRESSURE -- ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	53-24 also 54-12	2064-2282		ZrO_2; 0.025 >Hf.	Ta cell.
□	ND-2	2331-2480		Zirconia, ZrO_2.	Ta cell.
△	49-3	4573		ZrO_2.	



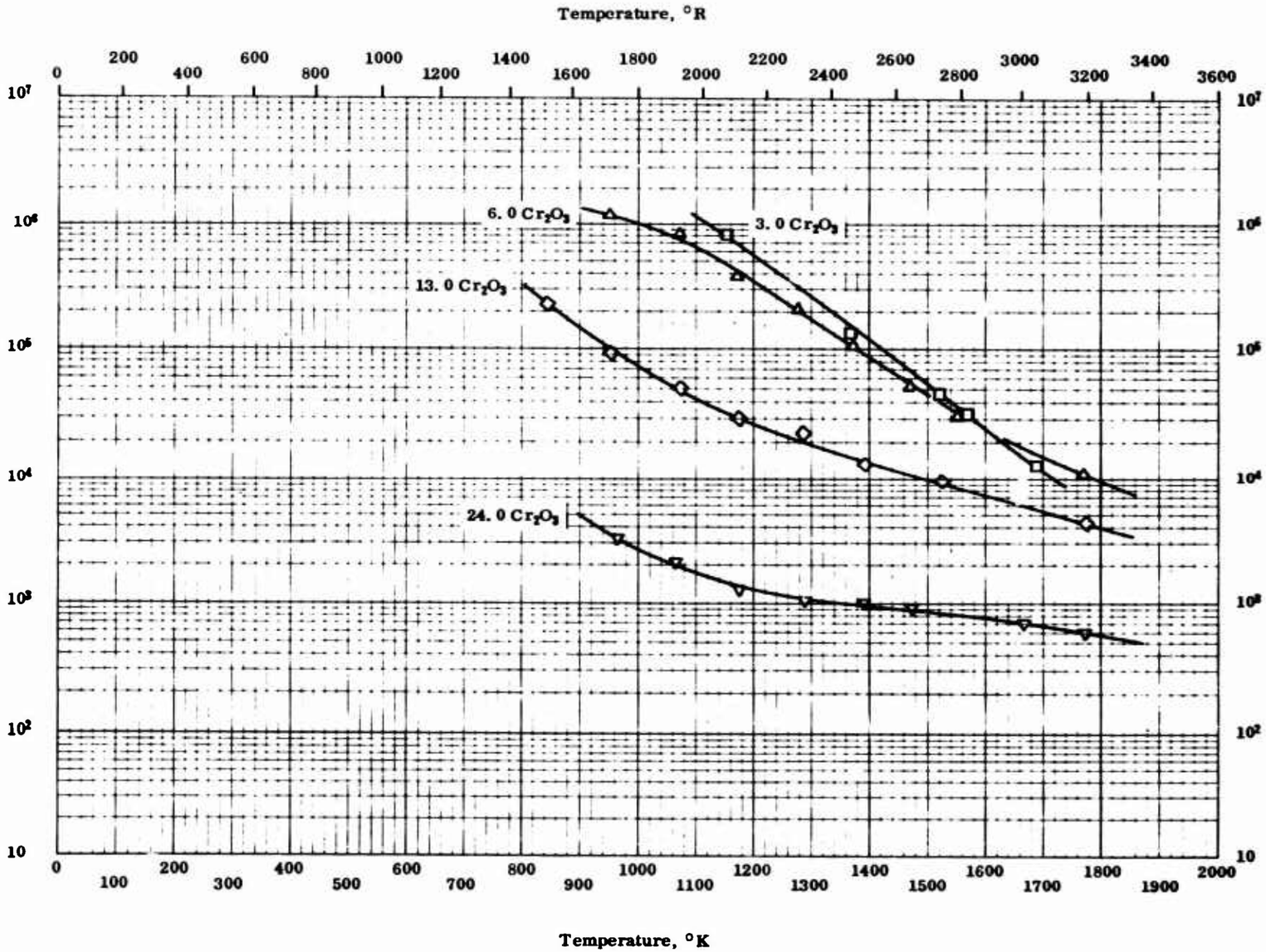
THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE + BERYLLIUM OXIDE + MAGNESIUM OXIDE

THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE + BERYLLIUM OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	46-4	293-1273		$MgO \cdot 4BeO \cdot Al_2O_3$; 41.29 BeO and 16.64 MgO; prepared from 97 pure MgO, 99.7 pure BeO, and 99+ pure Al_2O_3.	

TPRC



TPRC

ELECTRICAL RESISTIVITY -- ALUMINUM OXIDE + CHROMIUM SESQUIOXIDE

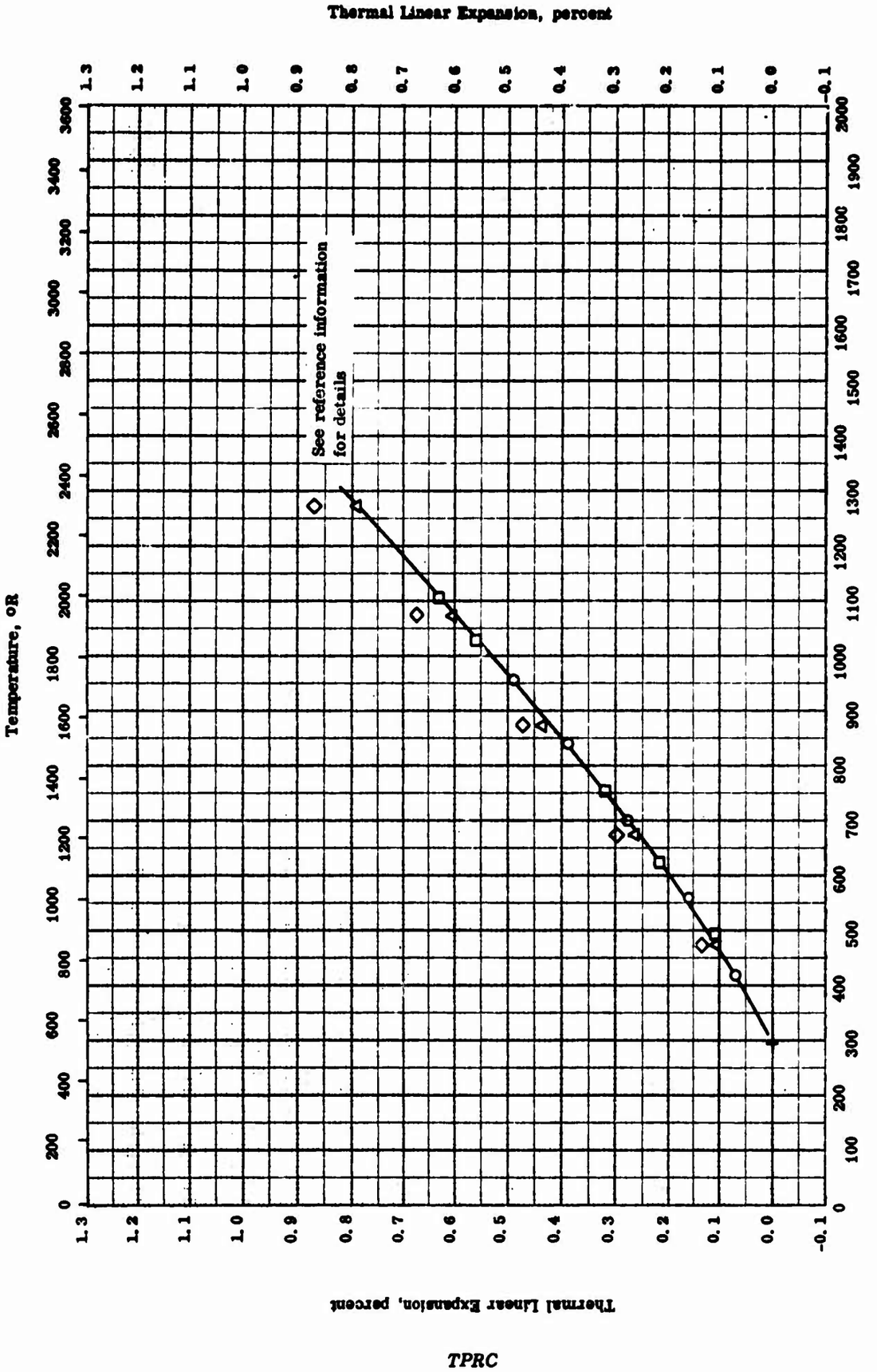
Electrical Resistivity, ohm cm

ELECTRICAL RESISTIVITY -- ALUMINUM OXIDE + CHROMIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	53-17	1153-1743		97 Al_2O_3 and 3 Cr_2O_3.	Oxides obtained by calcining the coprecipitated hydroxides of Al and Cr; fired 10 hrs at 1500 C.
△	53-17	953-1773		94 Al_2O_3 and 6 Cr_2O_3.	Same as above.
◇	53-17	843-1773		87 Al_2O_3 and 13 Cr_2O_3.	Same as above.
▽	53-17	963-1773		76 Al_2O_3 and 24 Cr_2O_3.	Same as above.

TPRC



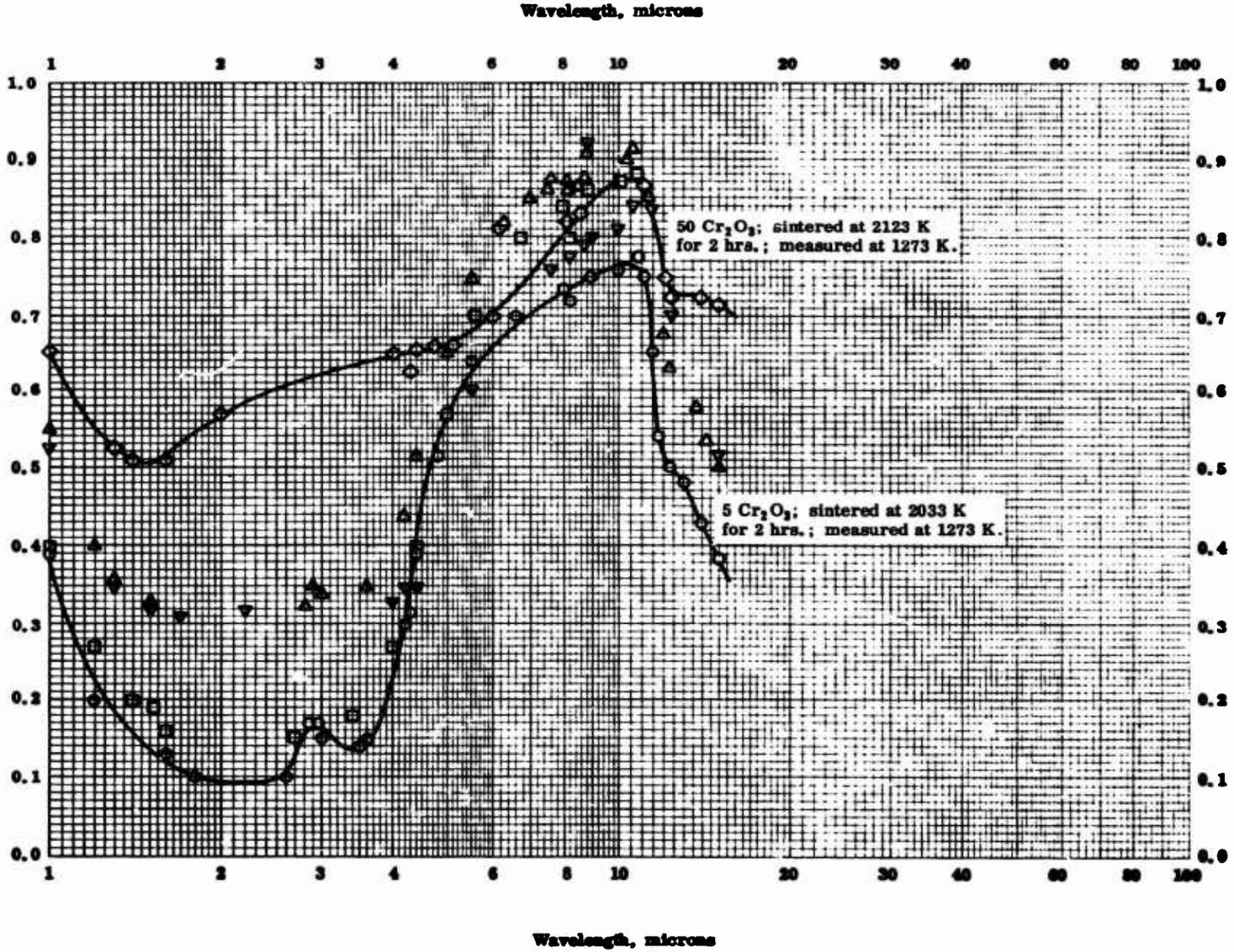
THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE + CHROMIUM SESQUIOXIDE

THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE + CHROMIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
△	60-36	299-1273		85.79 Al_2O_3 and 14.21 Cr_2O_3.	Al_2O_3 and Cr_2O_3 ball-milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15% binder (40 g Carbowax 20 M, 20 cc of 2% Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired to 1500 C for 17 hrs, cooled to room temperature in less than 30 min, and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
◇	60-36	299-1273		Same as above.	Same as above except measured along c-axis.
○	54-31	293-1073		10 Cr_2O_3.	Sintered at 3000 F.
□	54-31	293-1106		20 Cr_2O_3.	Same as above.

TPRC



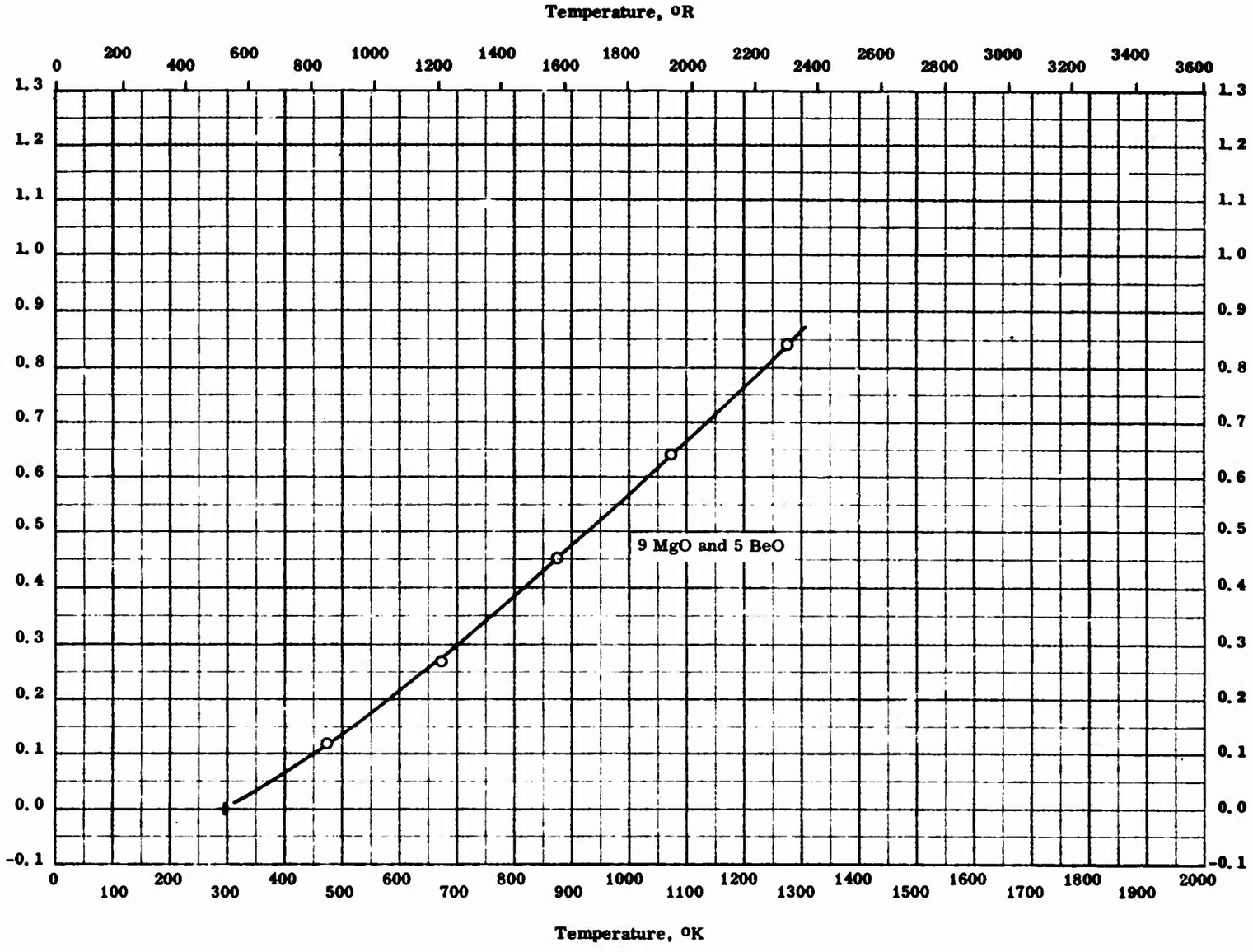
NORMAL SPECTRAL EMITTANCE — ALUMINUM OXIDE + CHROMIUM SESQUIOXIDE

NORMAL SPECTRAL EMITTANCE — ALUMINUM OXIDE + CHROMIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. ° K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	62-23	1273	1-15		95 Al_2O_3 and 5 Cr_2O_3; 0.038 in. thickness plate.	Sintered at 2033 K for 2 hrs; measured in air.
□	62-23	1273	1-15		90 Al_2O_3 and 10 Cr_2O_3; 0.054 in. thickness plate.	Same as above except sintered at 1948 K for 2 hrs.
△	62-23	1273	1-15		80 Al_2O_3 and 20 Cr_2O_3; 0.051 in. thickness plate.	Sintered at 1973 K for 2 hrs measured in air.
▽	62-23	1273	1-15		65 Al_2O_3 and 35 Cr_2O_3; 0.038 in. thickness plate.	Sintered at 2123 K for 2 hrs; measured in air.
◇	62-23	1273	1-15		50 Al_2O_3 and 50 Cr_2O_3; 0.038 in. thickness plate.	Sintered at 2123 K for 2 hrs; measured in air.

TPRC

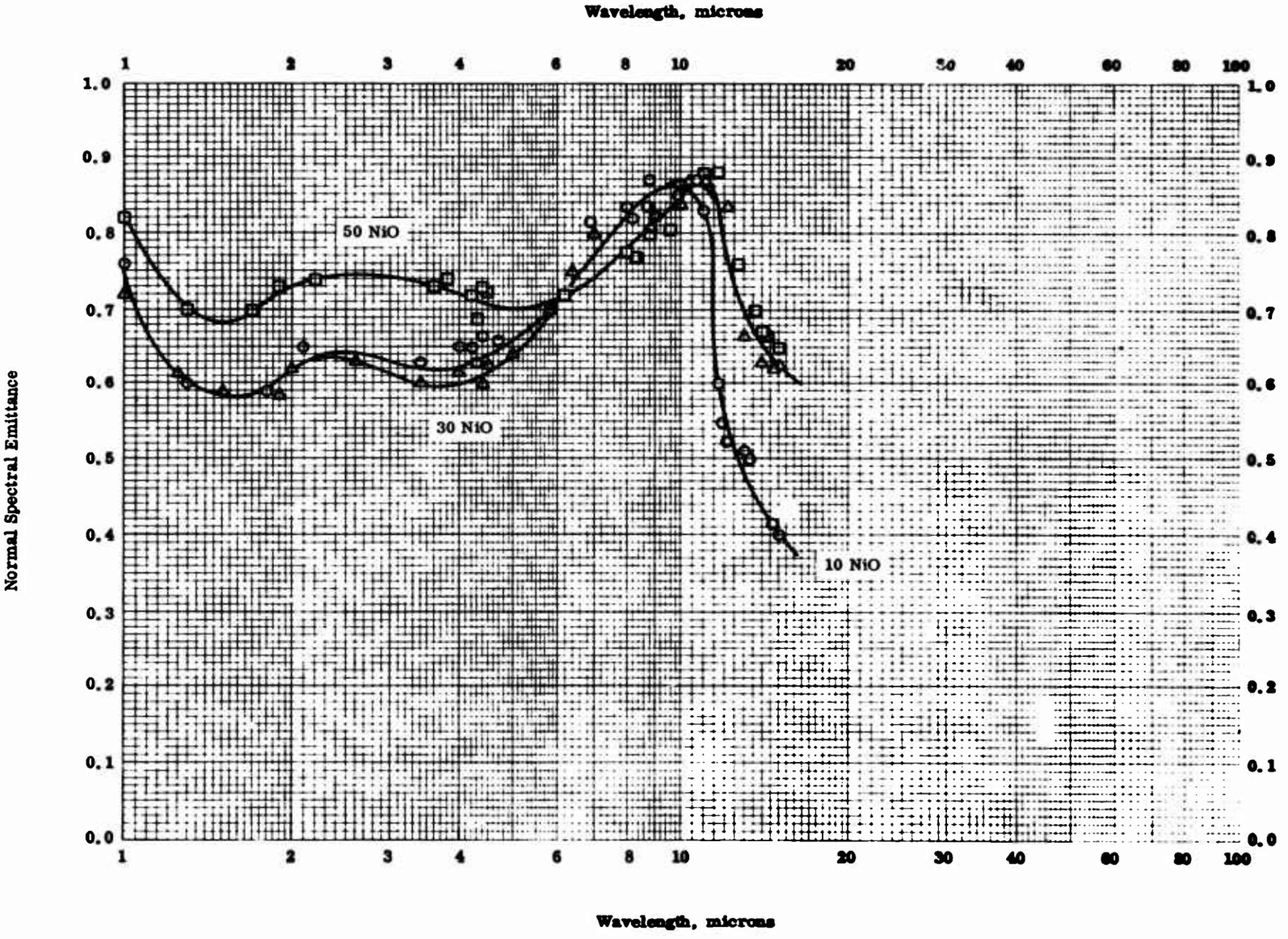


THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE + MAGNESIUM OXIDE + BERYLLIUM OXIDE

THERMAL LINEAR EXPANSION - ALUMINUM OXIDE + MAGNESIUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	46-4	293-1273		$MgO \cdot BeO \cdot 4Al_2O_3$; 8.52 MgO and 5.29 BeO; prepared from 97 pure MgO, 99.7 pure BeO, and 99^+ pure Al_2O_3.	



NORMAL SPECTRAL EMITTANCE -- ALUMINUM OXIDE + NICKEL MONOXIDE

NORMAL SPECTRAL EMITTANCE -- ALUMINUM OXIDE + NICKEL MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	62-23	1273	1-15		90 Al_2O_3 and 10 NiO; crystal structure corundum and nickel aluminate, 0.05 in. thickness.	Sintered at 2023 K for 2 hrs; measured in air; data taken from a curve.
△	62-23	1273	1-15		70 Al_2O_3 and 30 NiO, crystal structure nickel aluminate, 0.037 in. thickness plate.	Same as above.
□	62-23	1273	1-15		50 Al_2O_3 and 50 NiO, crystal structure nickel aluminate ($NiAl_2O_4$). 0.041 in. thickness plate.	Same as above.

PROPERTIES OF ALUMINUM OXIDE + NIOBIUM PENTOXIDE

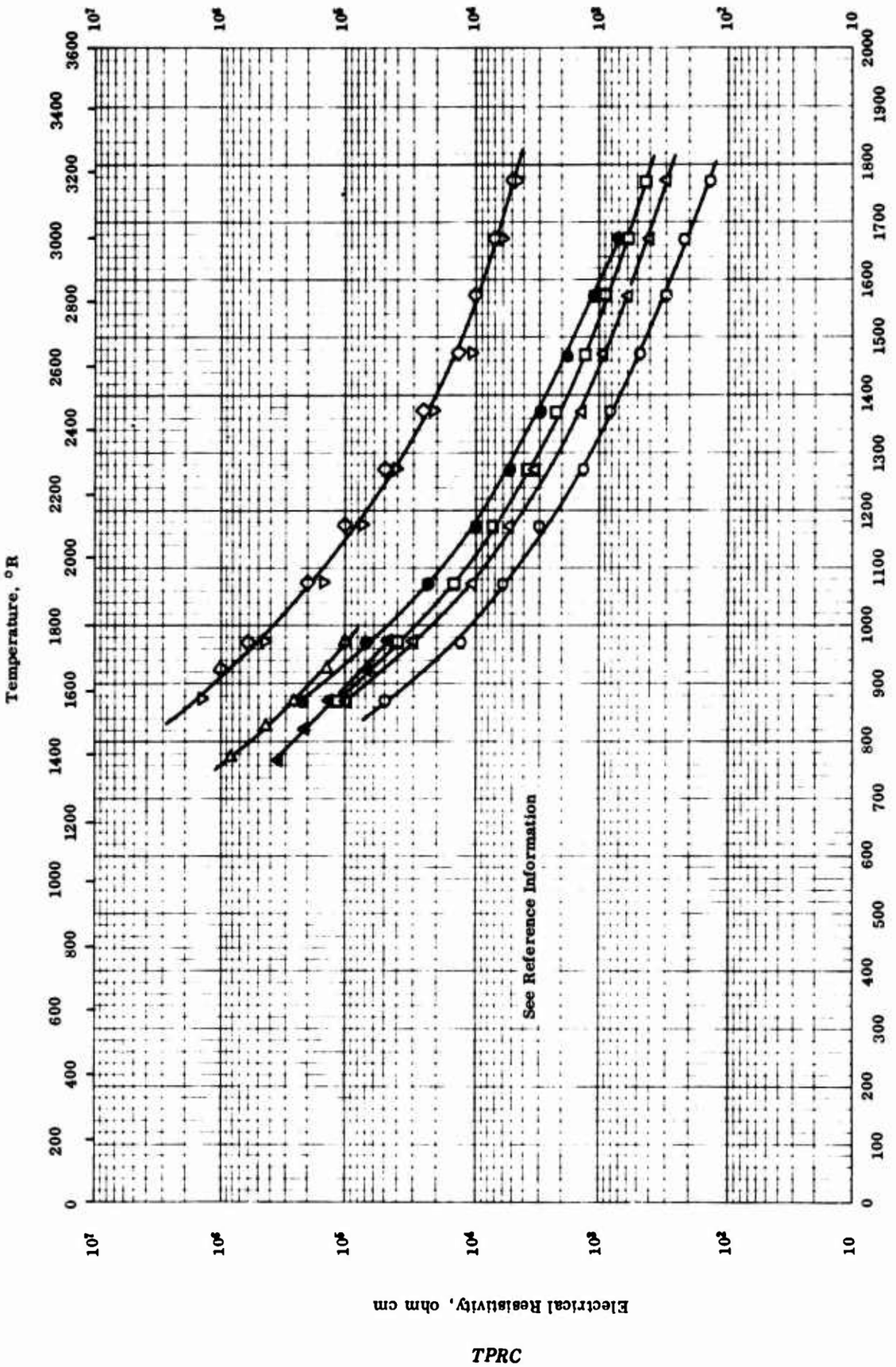
REPORTED VALUES

Melting Point	K	R
○ 39.75 Nb_2O_5	1783	3210
□ 46.80 Nb_2O_5	1768	3183

PROPERTIES OF ALUMINUM OXIDE + NIOBIUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-12	1783		60.25 Al_2O_3 and 39.75 Nb_2O_5; prepared from 99.5+ pure Al_2O_3 and 99.9 pure Nb_2O_5.	Corresponding to 4:1 mole ratio; measured approximate fusion temperature during sintering.
□	52-12	1768		53.20 Al_2O_3 and 46.80 Nb_2O_5; same raw material as above.	Corresponding to 3:1 mole ratio; same as above.



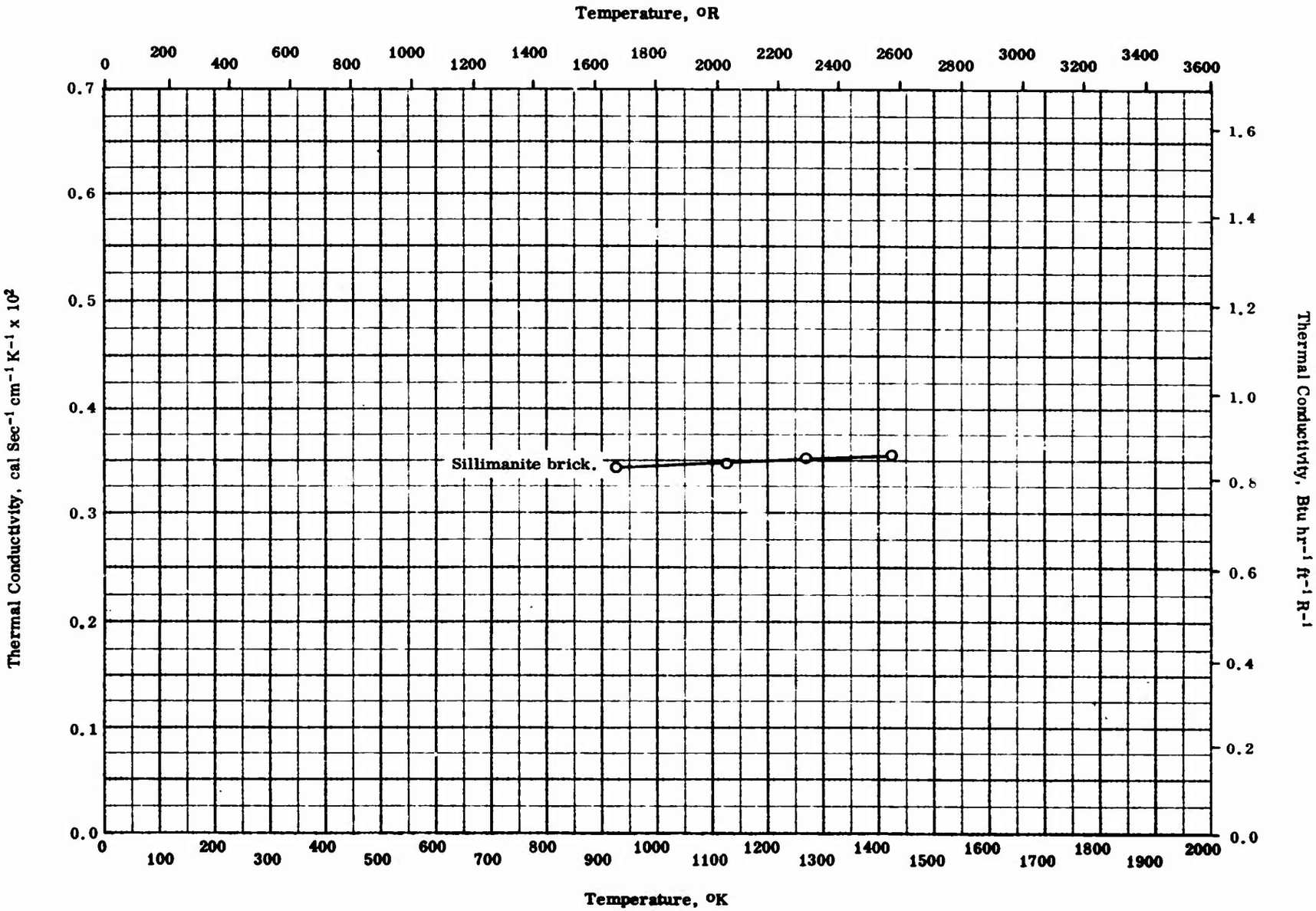
ELECTRICAL RESISTIVITY -- ALUMINUM OXIDE + SILICON DIOXIDE
(Alumina commercial firebrick)

ELECTRICAL RESISTIVITY -- ALUMINUM OXIDE + SILICON DIOXIDE
(Alumina commercial firebrick)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-16	873-1773		60 Al_2O_3 and 34 SiO_2; 24% porosity.	35-37 pyrometric cone equivalent.
□	53-16	873-1773		62 Al_2O_3 and 32 SiO_2; 21% porosity.	36-37 pyrometric cone equivalent.
△	53-16	873-1773		69 Al_2O_3 and 23 SiO_2; 23% porosity.	37-38 pyrometric cone equivalent.
◇	53-16	873-1773		64 Al_2O_3 and 32 SiO_2; 26% porosity; mullite type.	38+ pyrometric cone equivalent.
▽	53-16	873-1773		64 Al_2O_3 and 32 SiO_2; 22% porosity; mullite type.	37-38 pyrometric cone equivalent.
●	53-16	873-1773		Fused; mullite type.	Same as above.
▷	55-19	773-973		95 white corundum (95.55 Al_2O_3, 2.5 SiO_2, 0.30 CaO, 0.25 Fe_2O_3, 0.16 MgO, and 0.55 residue) and 5 clay (53.17 SiO_2. 31.6 Al_2O_3, 0.90 Fe_2O_3, 0.54 CaO, 0.30 MgO, and 12.96 residue).	Fired 2 hrs at 1400 C; plotted data average of 3 samples within ± 10%.
▲	55-19	773-973		50 white corundum and 50 clay; raw material same as above.	Same as above; author also gives data for 10, 20, 30, and 40% clay which lie between the above sample and this sample.

TPRC



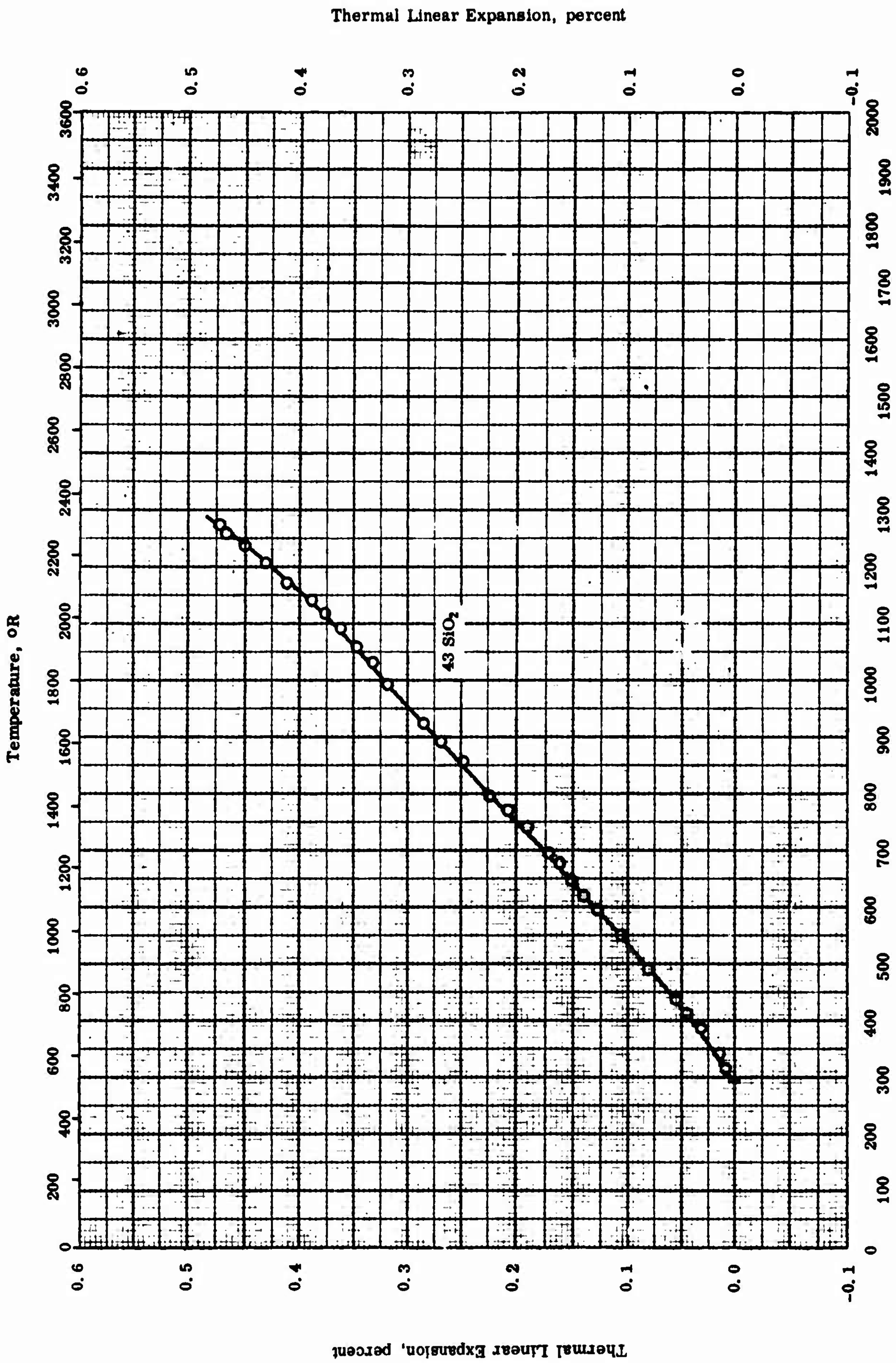
THERMAL CONDUCTIVITY -- ALUMINUM OXIDE + SILICON DIOXIDE

THERMAL CONDUCTIVITY -- ALUMINUM OXIDE + SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-2	923-1423	±5	Sillimanite brick; 57.34 Al_2O_3, 39.64 SiO_2, 1.26 TiO_2, 0.70 Fe_2O_3, 0.34 K_2O, 0.25 Na_2O, 0.24 MgO, 0.20 CaO, and 0.10 loss on ignition; bulk density 144 lb ft^3 (cf. theor. density 185); apparent porosity 22.2%.	

TPRC

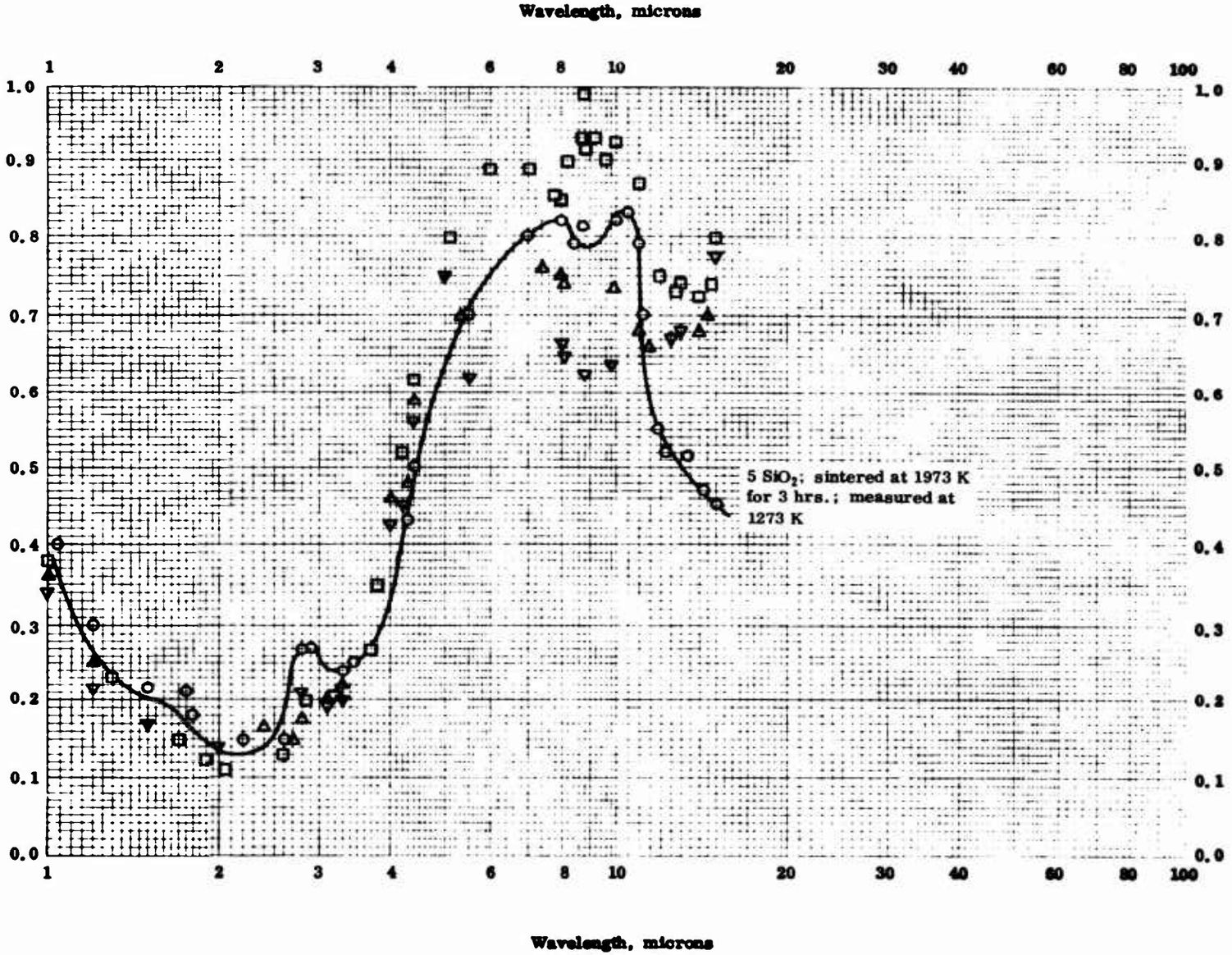


THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE + SILICON DIOXIDE

THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE + SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	61-37	298-1273		MV-30 refractory porcelain from McDanel Refractory Porcelain Co., Beaver Falls, Pa.; 56.2 Al_2O_3, 43.0 SiO_2, 0.40 Fe_2O_3, 0.32 KNaO, 0.12 CaO, and 0.10 MgO; zero apparent porosity.	Fabricated under commercial conditions, slip-cast, and fired to cone 30 down in 8-1/2 to 10 hrs.

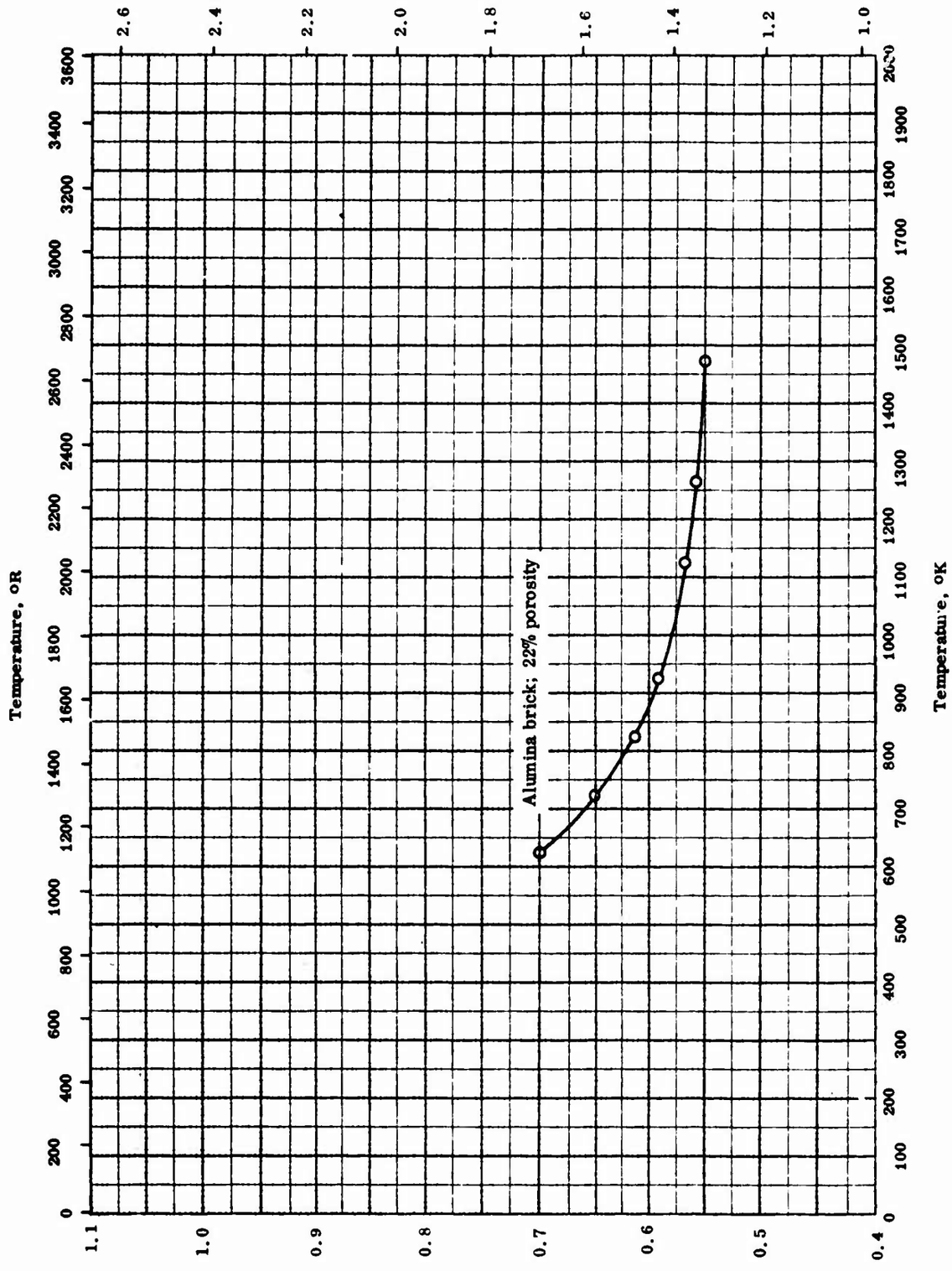


NORMAL SPECTRAL EMITTANCE -- ALUMINUM OXIDE + SILICON DIOXIDE

NORMAL SPECTRAL EMITTANCE -- ALUMINUM OXIDE + SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
○	62-23	1273	1-15		95 Al_2O_3 and 5 SiO_2, corundum; 0.11 in. thickness plate.	Sintered at 1973 K for 2 hrs; measured in air; data taken from a curve.
□	62-23	1273	1-15		90 Al_2O_3 and 10 SiO_2, corundum; 0.107 in. thickness plate.	Same as above.
△	62-23	1273	1-15		80 Al_2O_3 and 20 SiO_2, corundum-mullite, 0.032 in. thickness plate.	Same as above.
▽	62-23	1273	1-15		67 Al_2O_3 and 33 SiO_2, mullite-corundum, 0.033 in. thickness plate.	Same as above.



THERMAL CONDUCTIVITY -- ALUMINUM OXIDE - SILICON DIOXIDE + TITANIUM DIOXIDE

THERMAL CONDUCTIVITY -- ALUMINUM OXIDE + SILICON DIOXIDE + TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-2	623-1473	±5	Alumina brick; 86.9 Al_2O_3, 10.08 SiO_2, 2.08 TiO_2, 0.66 Fe_2O_3, 0.35 K_2O, 0.24 CaO, 0.10 Na_2O, 0.08 loss on ignition; bulk density 178 lb ft^{-3} (theoretical density 228.7); apparent porosity 22.1%.	

TPRC

PROPERTIES OF ALUMINUM OXIDE + THORIUM DIOXIDE

REPORTED VALUES

Melting Point	K	R
○ 39.30 ThO_2	2186 ±3	3935 ±5
□ 46.33 ThO_2	2188 ±5	3938 ±8

PROPERTIES OF ALUMINUM OXIDE + THORIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-26	2183-2189	± 2	60.70 Al_2O_3 and 39.30 ThO_2.	Corresponding to 4: 1 mole ratio; average of 3 - 5 tests by visual observation.
□	54-26	2183-2193	± 2	53.67 Al_2O_3 and 46.33 ThO_2.	Corresponding to 3: 1 mole ratio; same as above.

PROPERTIES OF ALUMINUM OXIDE + THORIUM DIOXIDE + BERYLLIUM OXIDE

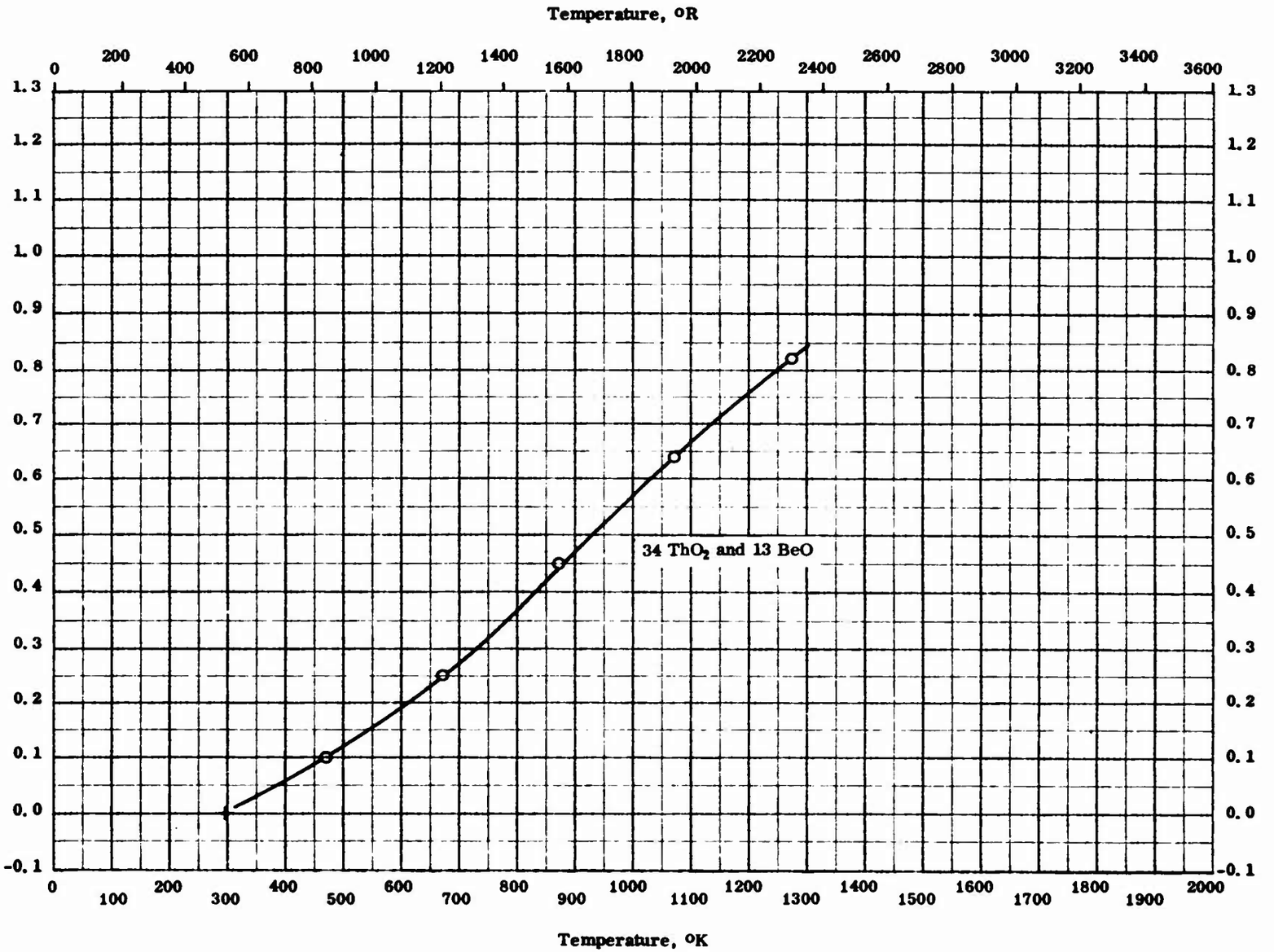
REPORTED VALUES

Melting Point	K	R
O 33.36 ThO_2 and 12.96 BeO	2082 ± 1	3748 ± 2

PROPERTIES OF ALUMINUM OXIDE + THORIUM DIOXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-26	2081-2083	± 2	53.68 Al_2O_3, 33.36 ThO_2, and 12.96 BeO.	Corresponding to 4: 1: 4 mole ratio; average of 3 - 5 tests by visual observation.



THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE + THORIUM DIOXIDE + BERYLLIUM OXIDE

THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE + THORIUM DIOXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	46-4	293-1273		$4BeO \cdot 4Al_2O_3 \cdot ThO_2$; 34.22 ThO_2, 12.96 BeO; prepared from 99.7 pure BeO, 99^+ pure Al_2O_3, and 99^+ pure ThO_2 (calcined).	Sintered.

PROPERTIES OF ALUMINUM OXIDE + URANIUM DIOXIDE

REPORTED VALUES

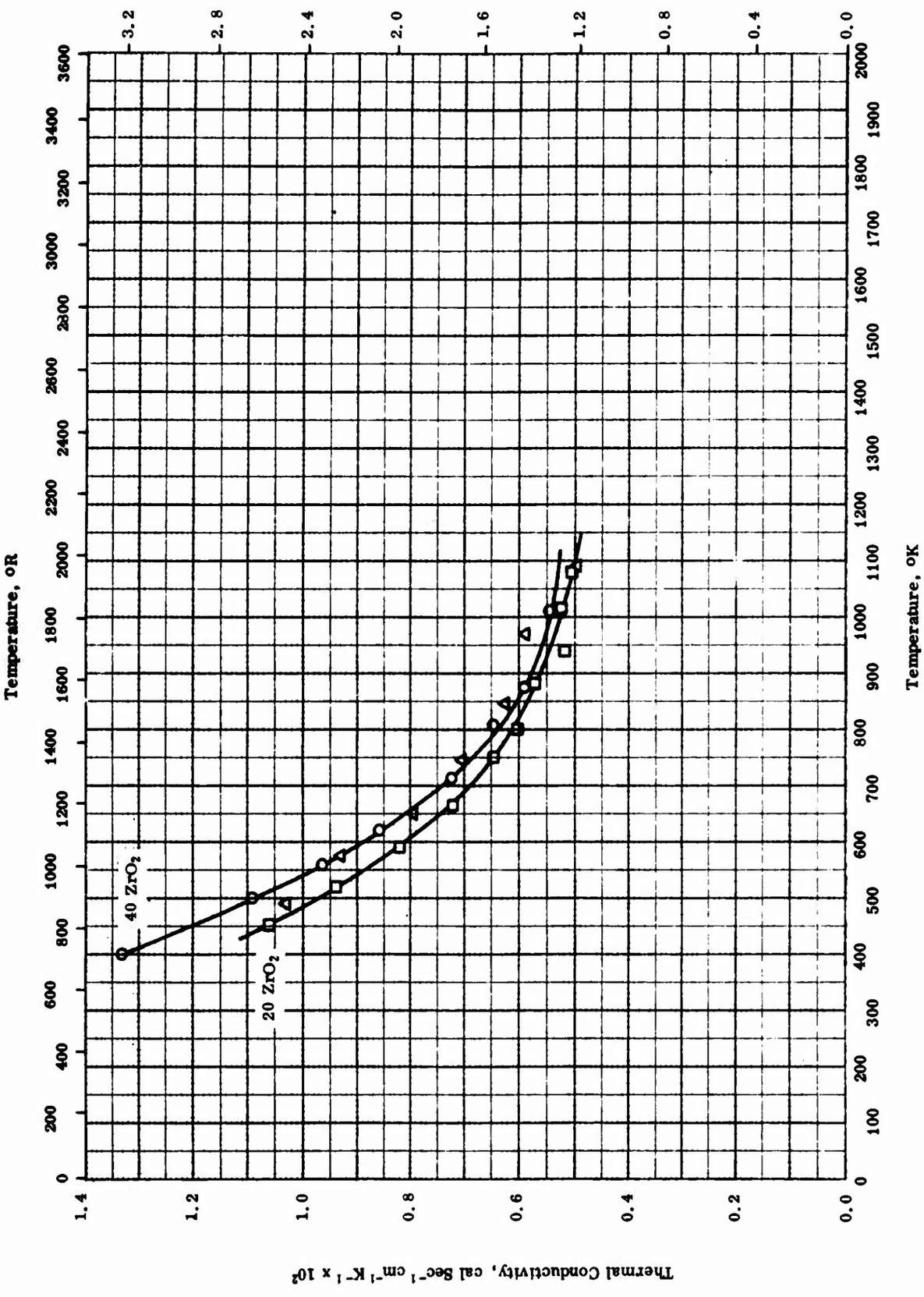
Density	g cm^{-3}	lb ft^{-3}
○ 21 $U^{235}O_2$	4.415 ± 0.015	275.5 ± 0.5
□ Same as above.	4.58*	286*

*Most probable value for this compound.

PROPERTIES OF ALUMINUM OXIDE + URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	57-32	298		79 Al_2O_3 and 21 $U^{235}O_2$.	Mixed enriched UO_2 and Fisher Al_2O_3 powder, dry milled 16 hrs, granulated with 1% PVA and water, drying 0.2% Sterotex added; pressed at 27400 psi, and sintered 14 hrs at 1750 C in H_2 atm.
□	57-32	298		Same as above.	Same as above; density computed from x-ray measurement.



THERMAL CONDUCTIVITY -- ALUMINUM OXIDE + ZIRCONIUM DIOXIDE

THERMAL CONDUCTIVITY -- ALUMINUM OXIDE + ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	55-2	488-1093		60 Al_2O_3 and 40 ZrO_2.	Sintered.
□	55-2	451-1078		80 Al_2O_3 and 20 ZrO_2.	Sintered.
△	55-2	400-1008		90 Al_2O_3 and 10 ZrO_2.	Sintered.

TPRC

PROPERTIES OF ALUMINUM OXIDE + ZIRCONIUM DIOXIDE + BERYLLIUM OXIDE

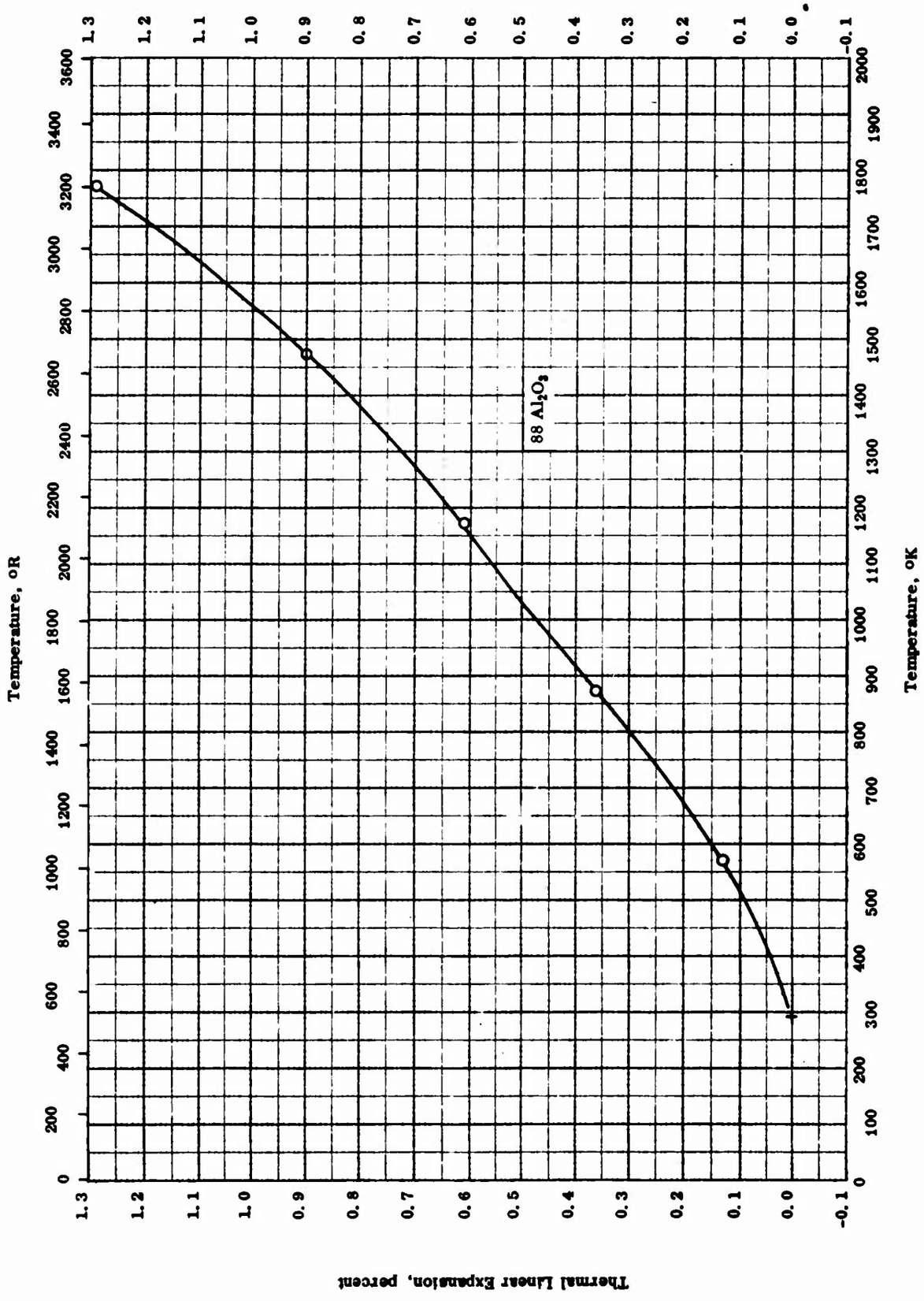
REPORTED VALUES

Melting Point	K	R
○ 32.67 ZrO_2 and 13.26 BeO	2043 ± 10	3678 ± 18

PROPERTIES OF ALUMINUM OXIDE + ZIRCONIUM DIOXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-26	2033-2053	± 2	54.07 Al_2O_3, 32.67 ZrO_2, and 13.26 BeO.	Corresponding to 2: 1: 2 mole ratio; average of 3 - 5 tests by visual observations.



THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE + ΣX_i

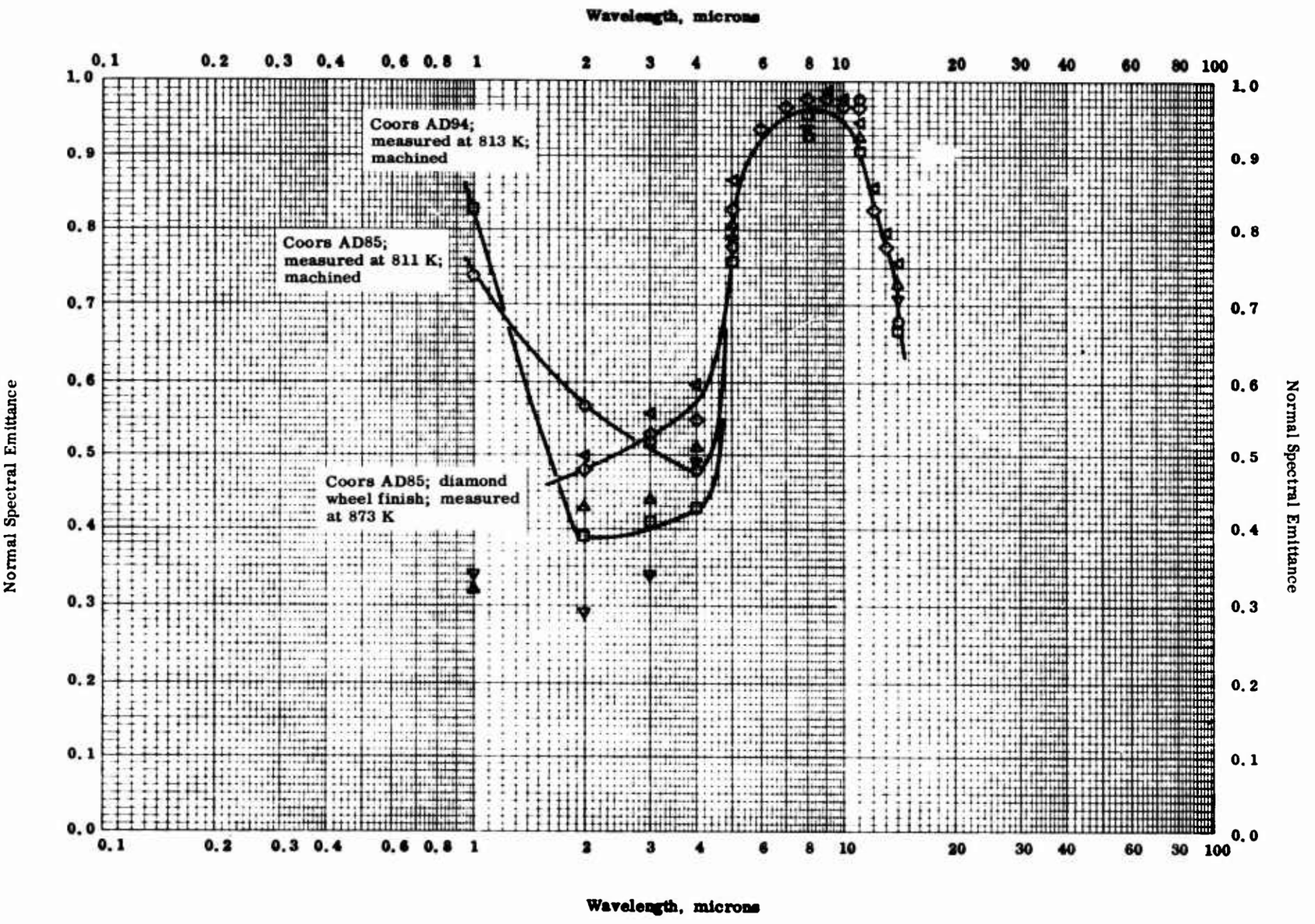
Thermal Linear Expansion, percent

THERMAL LINEAR EXPANSION -- ALUMINUM OXIDE + ΣX_i

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	56-28	573-1773		88 Al_2O_3; clay bonded fused grain.	

TPRC

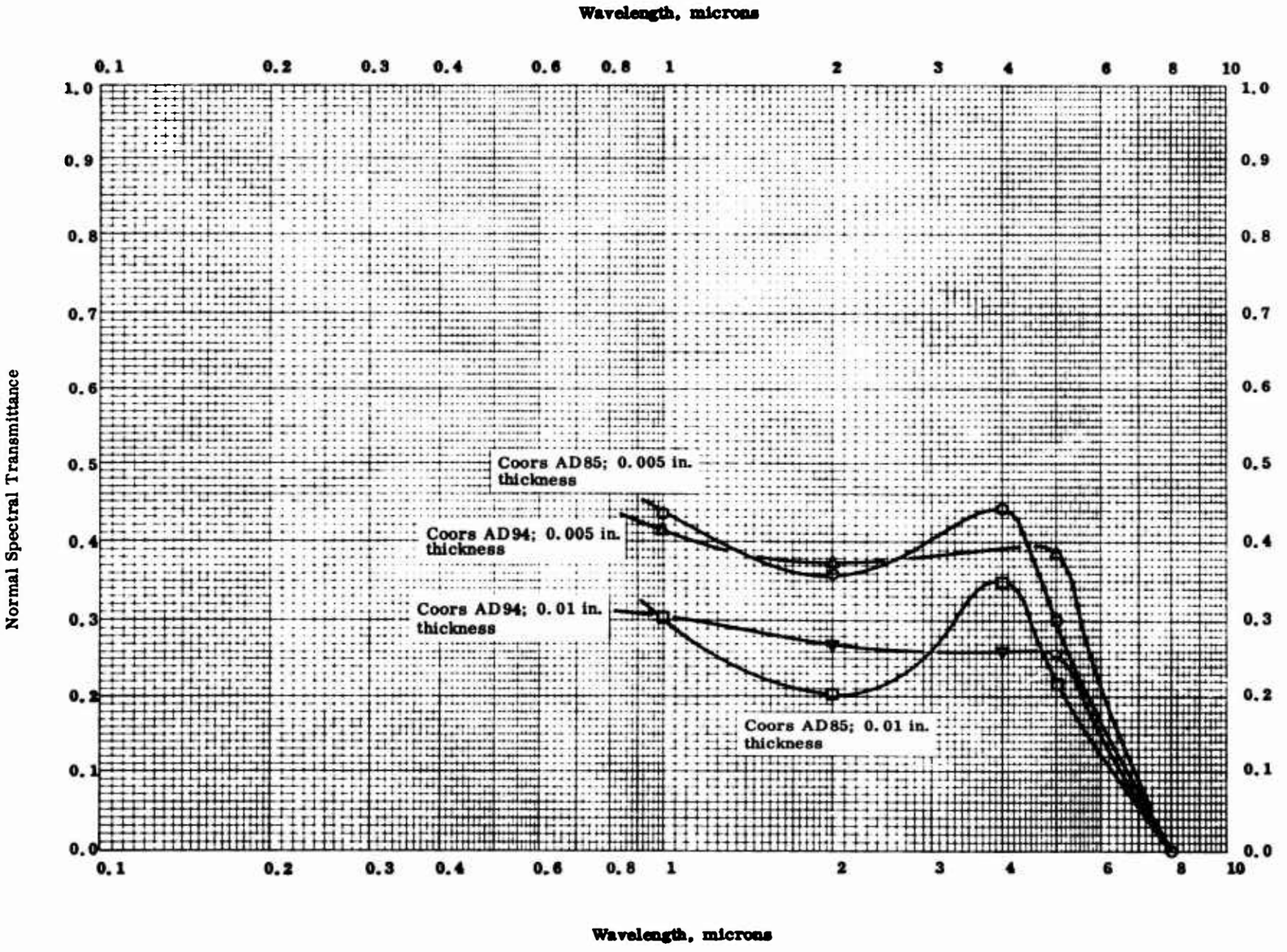


NORMAL SPECTRAL EMITTANCE -- ALUMINUM OXIDE + ΣX_i

NORMAL SPECTRAL EMITTANCE -- ALUMINUM OXIDE + ΣX_i

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range μ	Rept. Error%	Sample Specifications	Remarks
○	64-12	811	1-14	±5	Al_2O_3, Coors AD85; 85 pure.	Machined surface.
△	64-12	1513	1-14	±5	Same as above.	Same as above.
□	64-12	813	1-14	±5	Al_2O_3, Coors AD94; 94 pure.	Same as above.
▽	64-12	1591	1-14	±5	Same as above.	Same as above.
◇	60-30	873	2-14	±4	Al_2O_3, Coors AD85; 85 pure.	Ultrasonically machined, diamond wheel finish; measured in air.
◁	60-30	1303	1-14	±4	Same as above.	Same as above.

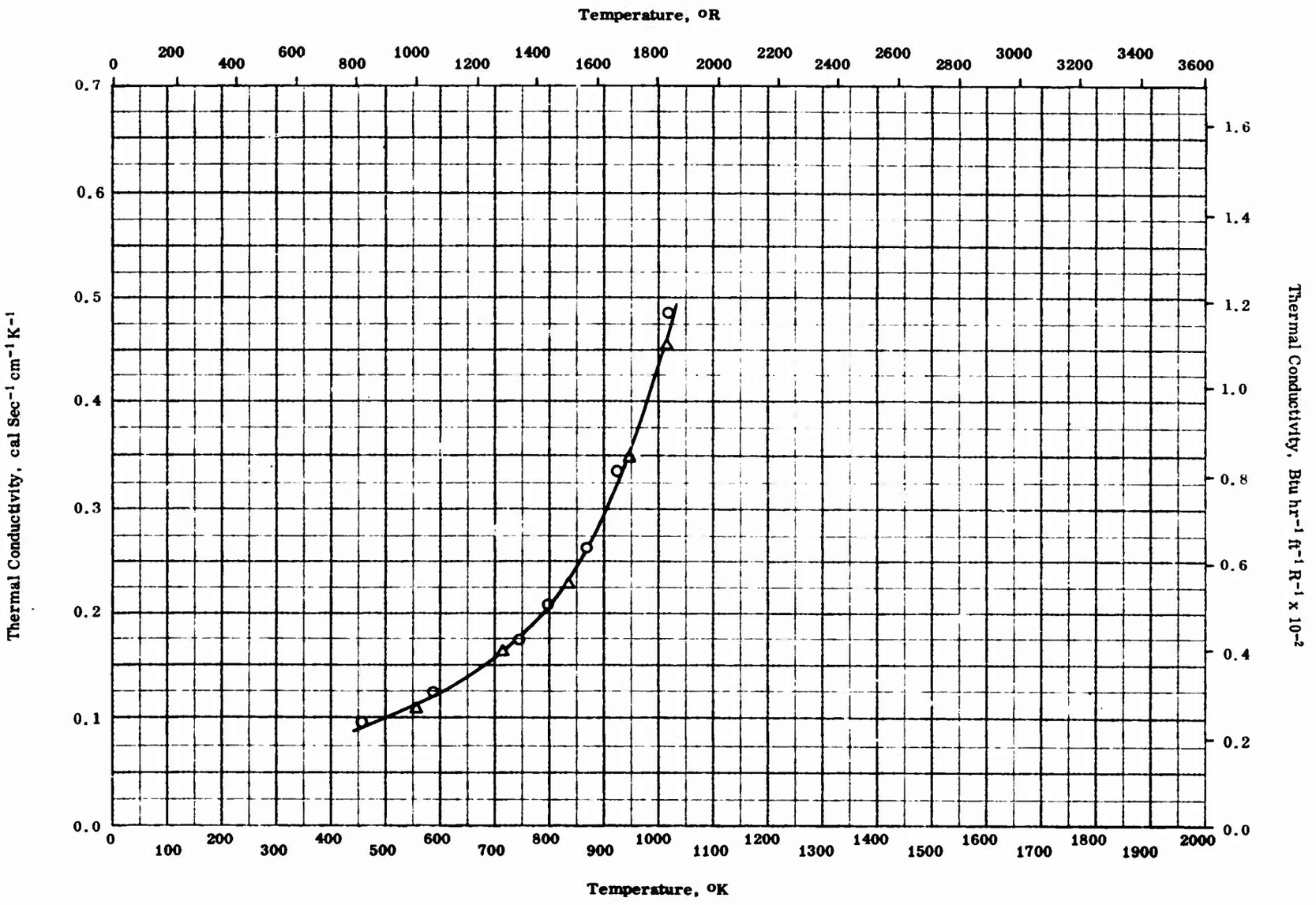


NORMAL SPECTRAL TRANSMITTANCE -- ALUMINUM OXIDE + ΣX_i

NORMAL SPECTRAL TRANSMITTANCE -- ALUMINUM OXIDE + ΣX_i

REFERENCE INFORMATION

Symbol	Ref.	Temp. ° K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
O	64-12	298	1-8	±5	Coors AD85; 85 Al_2O_3; 0.005 in. thickness.	
□	64-12	298	1-8	±5	Same as above; 0.01 in. thickness.	
△	64-12	298	1-8	±5	Coors AD94; 94 Al_2O_3; 0.005 in. thickness.	
▽	64-12	298	1-8	±5	Same as above; 0.01 in. thickness.	



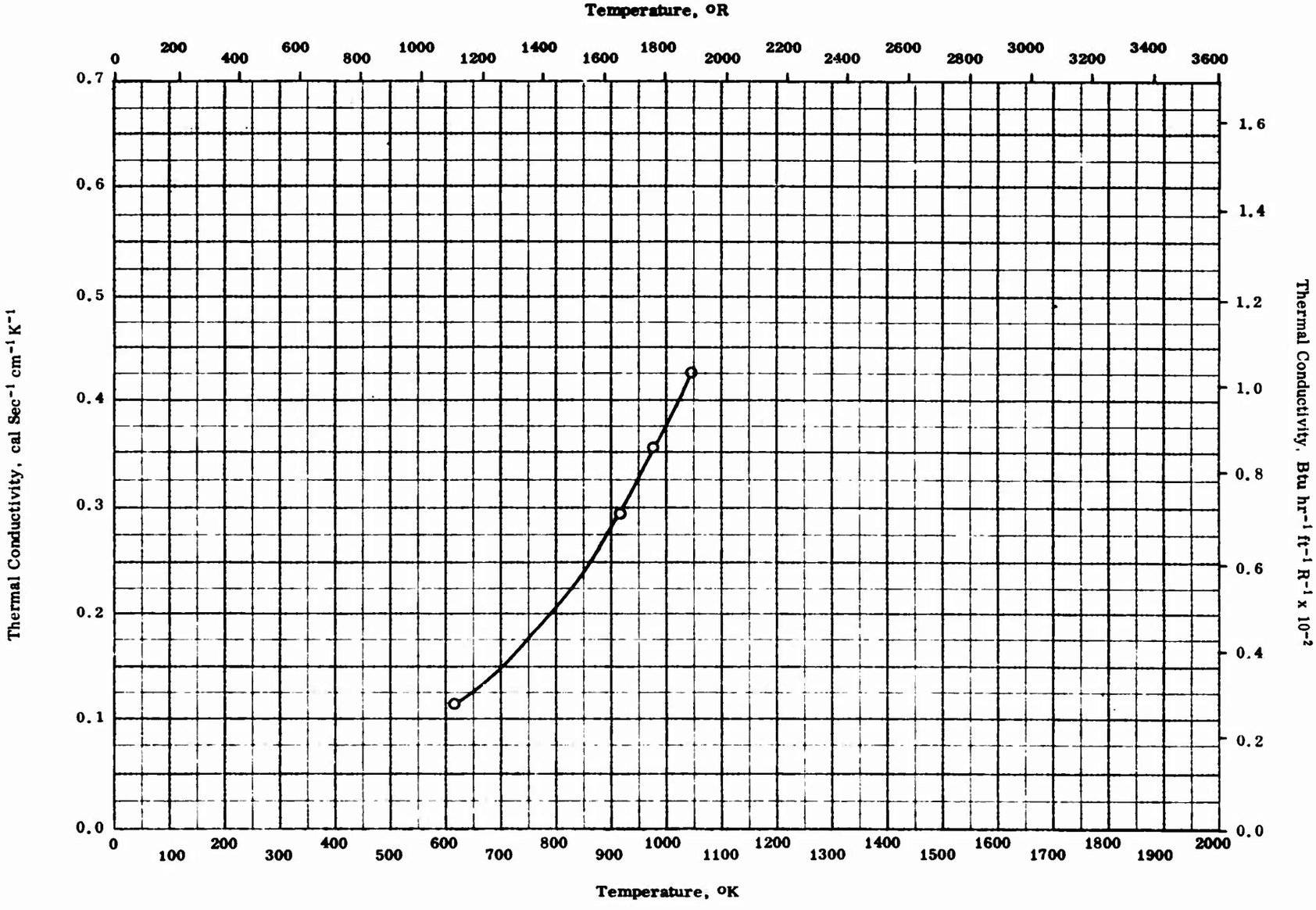
THERMAL CONDUCTIVITY -- BARIUM OXIDE + STRONTIUM OXIDE

THERMAL CONDUCTIVITY -- BARIUM OXIDE + STRONTIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	55-8	458-1018		An equimolecular mixture of polycrystalline BaO and SrO.	
Δ	55-8	558-1013		Same as above.	

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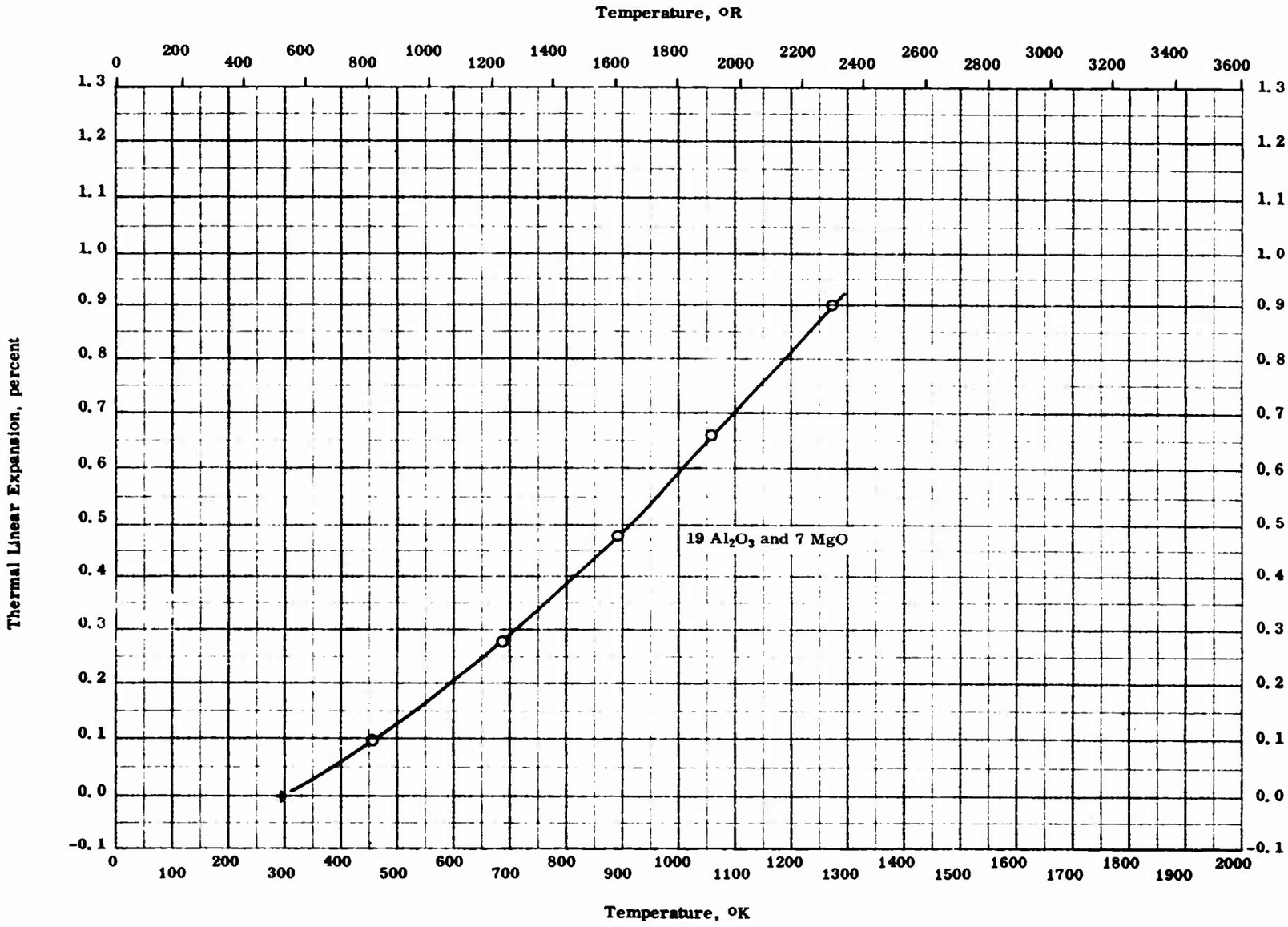


THERMAL CONDUCTIVITY -- BARIUM OXIDE + STRONTIUM OXIDE + ZIRCONIUM DIOXIDE

THERMAL CONDUCTIVITY -- BARIUM OXIDE + STRONTIUM OXIDE + ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	55-8	618-1043		An equimolecular mixture of polycrystalline BaO and SrO with 2.5 ZrO_2 added.	

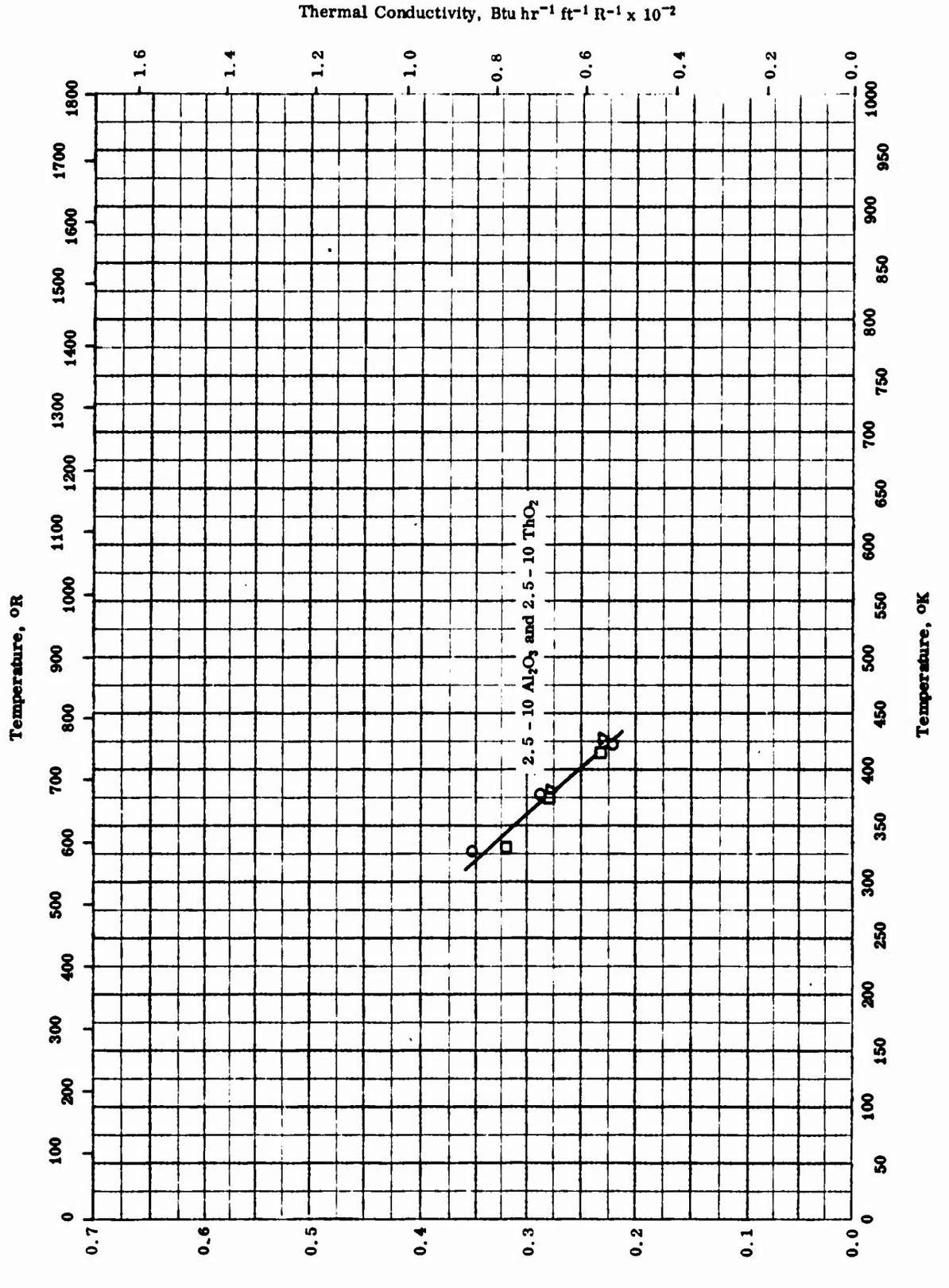


THERMAL LINEAR EXPANSION -- BERYLLIUM OXIDE + ALUMINUM OXIDE + MAGNESIUM OXIDE

THERMAL LINEAR EXPANSION -- BERYLLIUM OXIDE + ALUMINUM OXIDE +MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	46-4	293-1273		$MgO \cdot 16\ BeO \cdot Al_2O_3$; 73.7 BeO, 18.80 Al_2O_3, and 7.43 MgO; prepared from 97 pure MgO, 99.7 pure BeO, and 99+ pure Al_2O_3.	



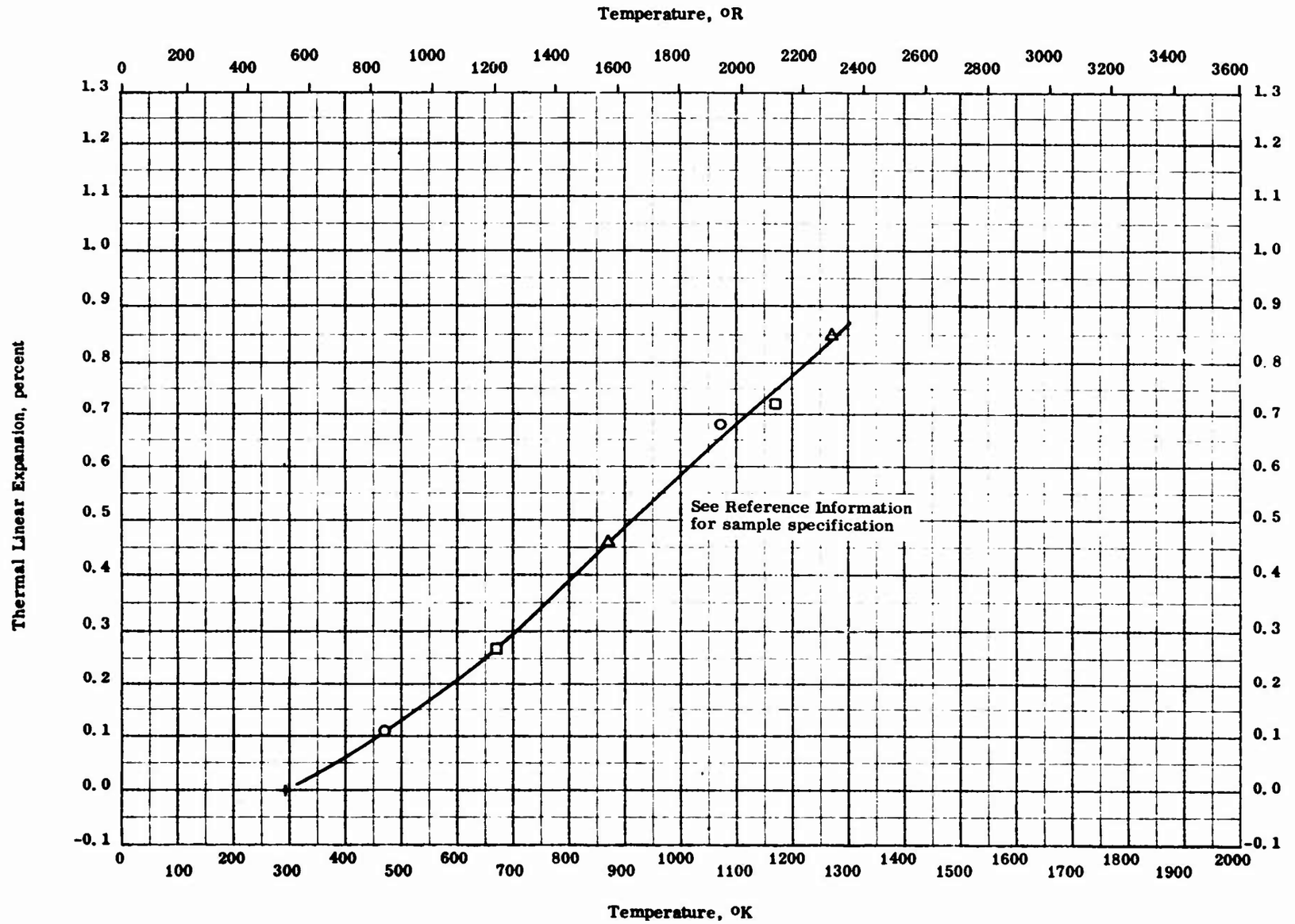
THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + ALUMINUM OXIDE + THORIUM DIOXIDE

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + ALUMINUM OXIDE + THORIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	50-2	329-423		95 BeO, 2.5 Al_2O_3, and 2.5 ThO_2; particle size passing 325 mesh for all raw materials. [Author's design.: A]	Samples formed at 10,000 psi and matured at 1700 C; crystalline phases of BeO, ThO_2, $MgO \cdot Al_2O_3$ and MgO present.
□	50-2	330-415		90 BeO, 5 Al_2O_3, and 5 ThO_2; same as above. [Author's design.: B]	Same as above.
▽	50-2	331-427		80 BeO, 10 Al_2O_3, and 10 ThO_2; same as above. [Author's design.: C]	Same as above.

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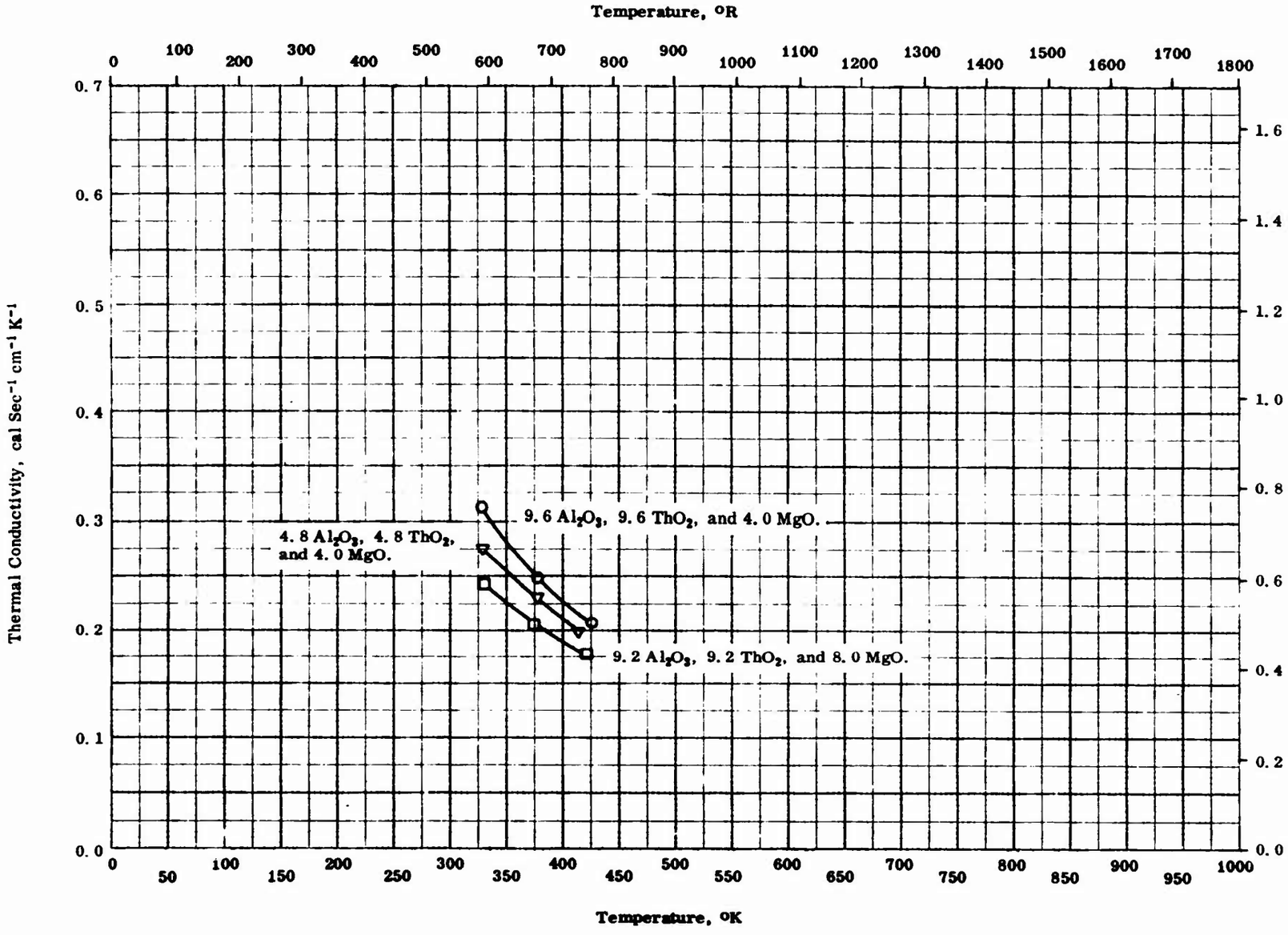


THERMAL LINEAR EXPANSION -- BERYLLIUM OXIDE + ALUMINUM OXIDE + THORIUM DIOXIDE

THERMAL LINEAR EXPANSION -- BERYLLIUM OXIDE + ALUMINUM OXIDE + THORIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	46-4	293-1073		48 BeO · 4 Al_2O_3 · ThO_2; 64.11 BeO, 21.78 Al_2O_3, and 14.11 ThO_2; prepared from 99.7 pure BeO, 99+ pure Al_2O_3, and 99+ pure ThO_2 (calcined).	
□	46-4	293-1173		48 BeO · 10 Al_2O_3 · ThO_2; 48.33 BeO, 41.04 Al_2O_3, and 10.63 ThO_2; raw materials same as above.	
△	46-4	293-1273		18 BeO · 4 Al_2O_3 · ThO_2; 40.12 BeO, 39.34 Al_2O_3, and 23.54 ThO_2; raw materials same as above.	

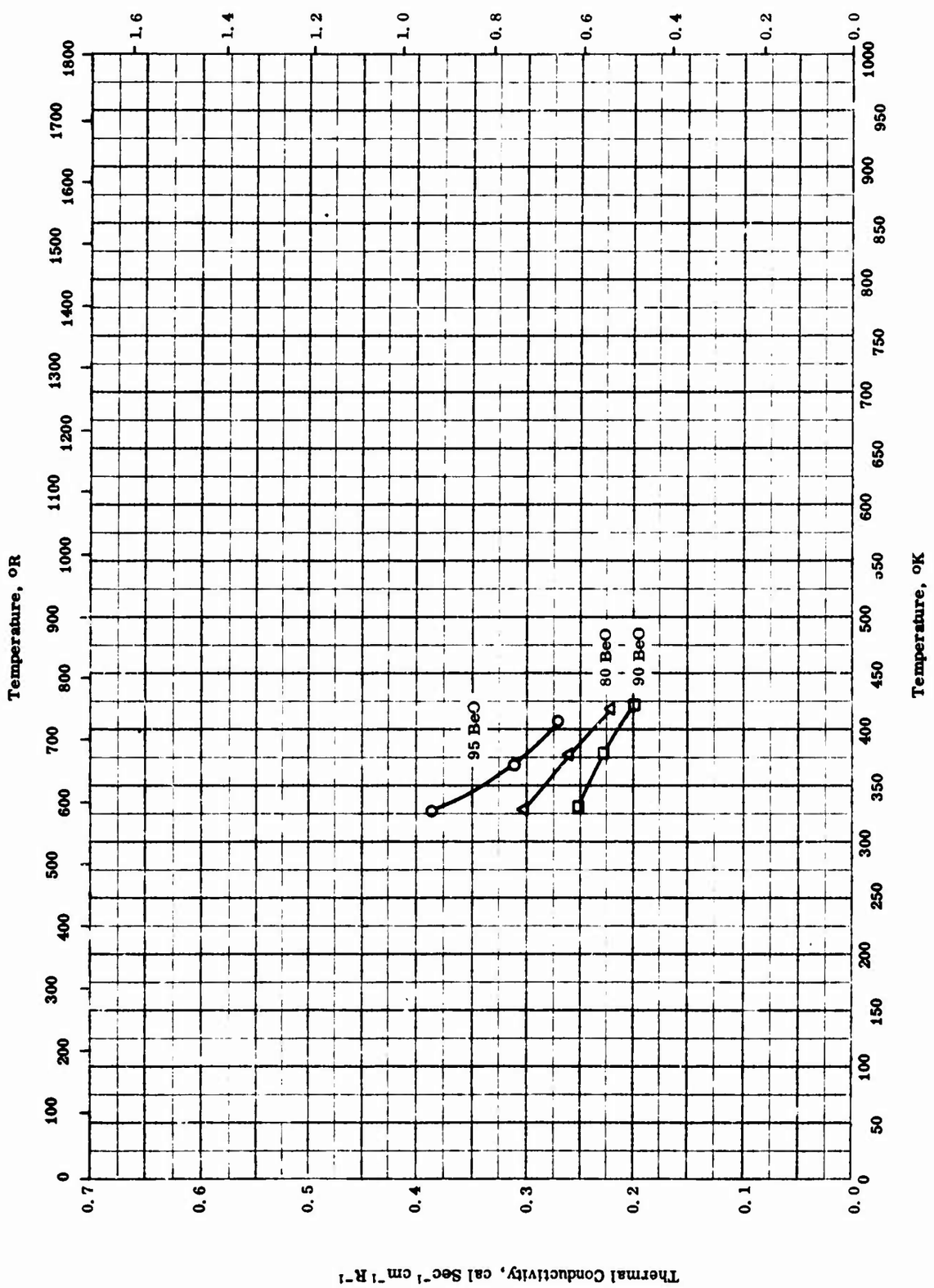


THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + ALUMINUM OXIDE +
+ THORIUM DIOXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + ALUMINUM OXIDE + + THORIUM DIOXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▽	50-2	329-416		86.4 BeO, 4.8 Al_2O_3, 4.8 ThO_2, and 4.0 MgO; particle size passing -325 mesh for all raw materials. [Author's design.: B4]	Formed at a pressure of 10,000 psi and matured at 1650 C; crystalline phases of BeO, ThO_2, $MgO \cdot Al_2O_3$, and MgO present.
○	50-2	328-425		76.8 BeO, 9.6 Al_2O_3, 9.6 ThO_2, and 4.0 MgO; particle size- 325 mesh for all raw materials. [Author's design.: C4]	Same as above.
□	50-2	329-421		73.6 BeO, 9.2 Al_2O_3, 9.2 ThO_2, and 8.0 MgO; particle size- 325 mesh for all raw materials. [Author's design.: C8]	Same as above.

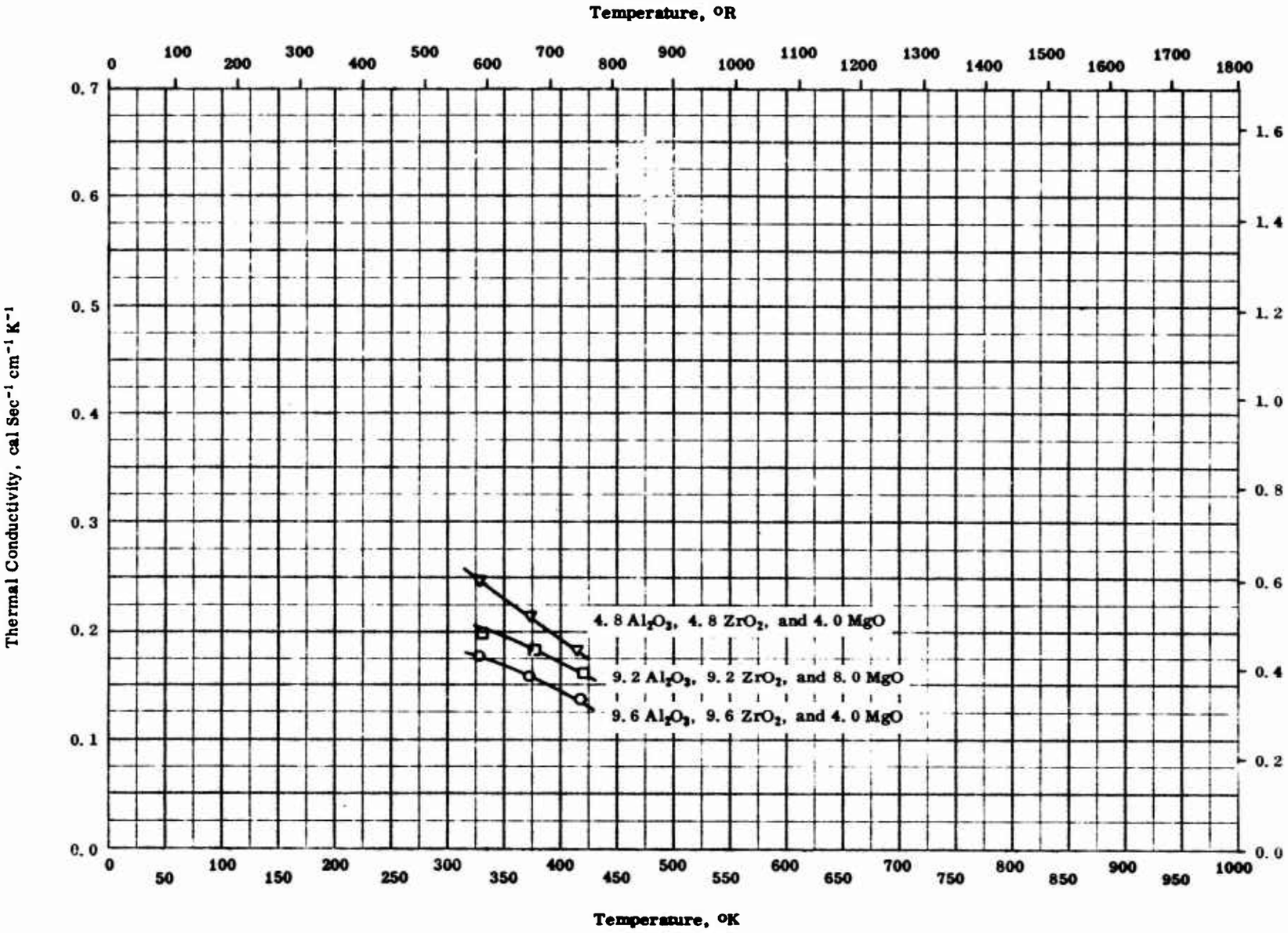


THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + ALUMINUM OXIDE + ZIRCONIUM DIOXIDE

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + ALUMINUM OXIDE + ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	50-2	327-407		95 BeO, 2.5 Al_2O_3, and 2.5 ZrO_2; particle size passing -325 mesh for all raw materials. [Author's design. = N]	Sample formed at 10,000 psi, and matured at 1700 C; crystalline phases of BeO, ZrO_2, $BeO \cdot Al_2O_3$ and MgO present.
□	50-2	331-421		90 BeO, 5 Al_2O_3, and 5 ZrO_2; same as above. [Author's design.: O]	Same as the above.
△	50-2	330-419		80 BeO, 10 Al_2O_3, and 10 ZrO_2; same as above. [Author's design.: P]	Same as the above.

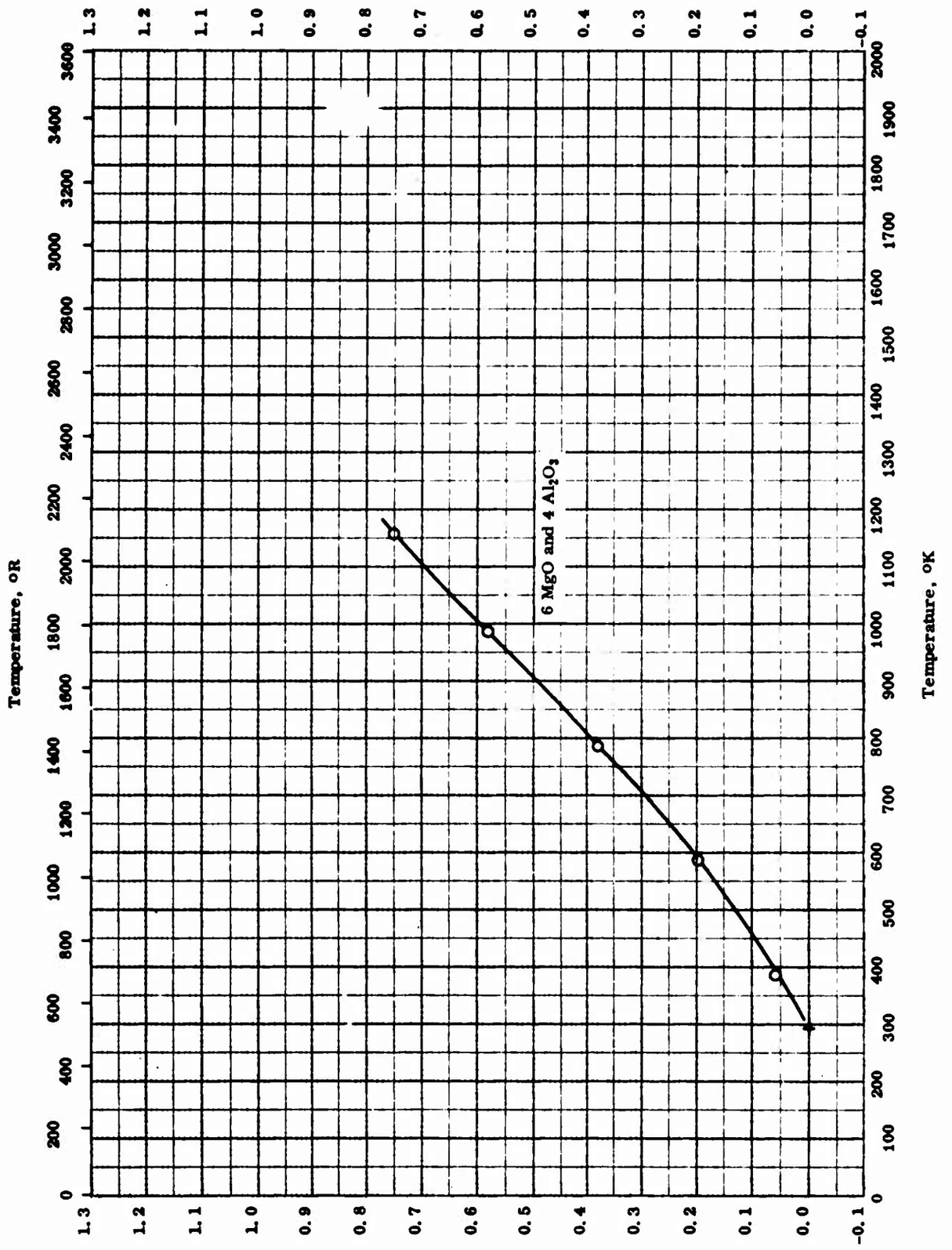


THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + ALUMINUM OXIDE +
+ ZIRCONIUM DIOXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + ALUMINUM OXIDE + + ZIRCONIUM DIOXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▽	50-2	328-414		86.4 BeO, 4.8 Al_2O_3, 4.8 ZrO_2; 4.0 MgO; particle size passing -325 mesh for all raw materials. [Author's design.: O4]	Samples formed at 10,000 psi and matured at 1550 C; crystalline phases of BeO, ZrO_2, $BeO \cdot Al_2O_3$ and MgO present.
○	50-2	328-417		76.9 BeO, 9.6 Al_2O_3, 9.6 ZrO_2, 4.0 MgO; particle size -325 mesh for all raw materials. [Author's design.: P4]	Same as the above specimen except matured at 1650 C.
□	50-2	330-420		73.6 BeO, 9.2 Al_2O_3, 9.2 ZrO_2, and 8.0 MgO; particle size -325 mesh for all raw materials. [Author's design.: P8]	Same as above except matured at 1550 C.



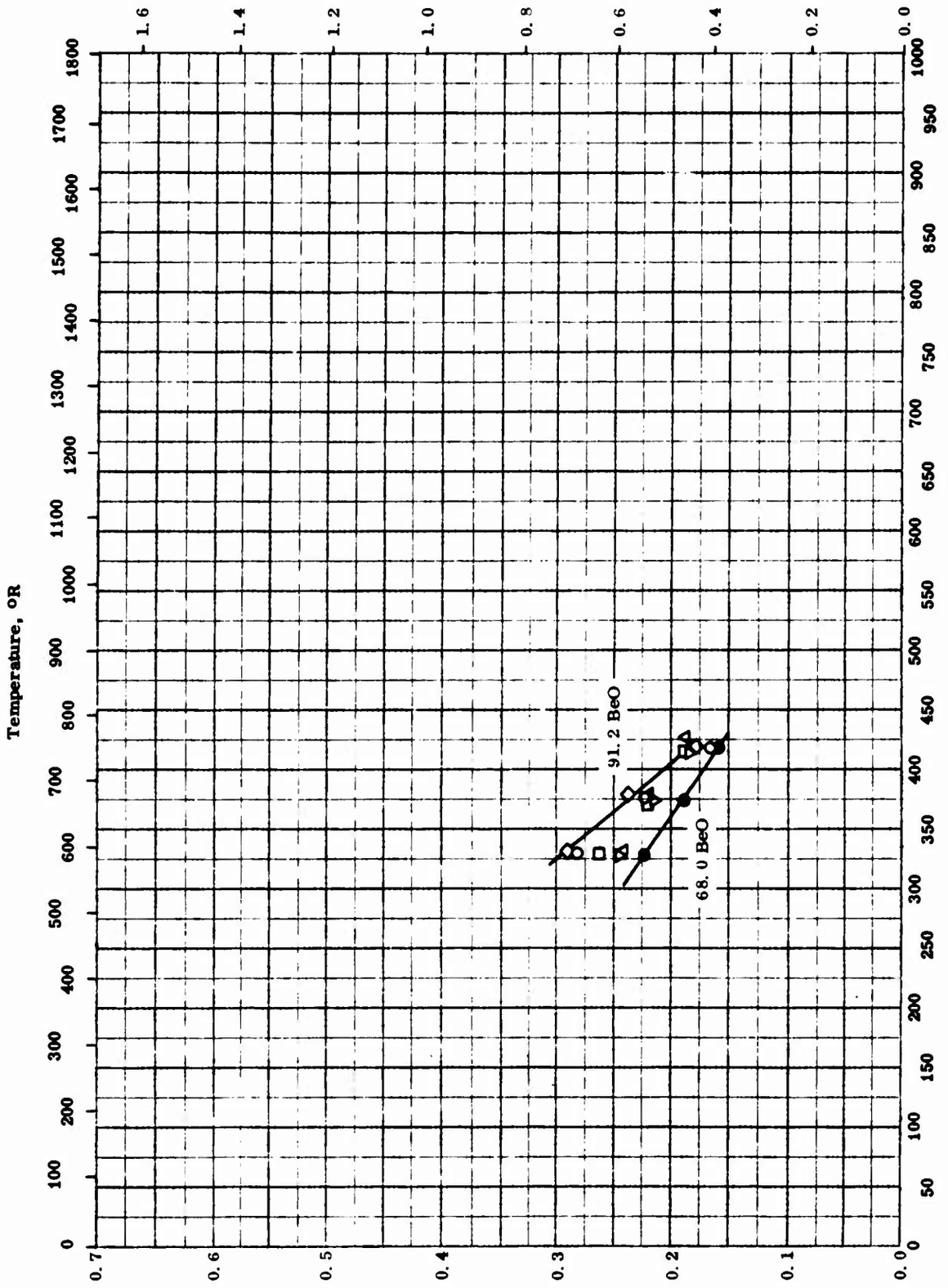
THERMAL LINEAR EXPANSION -- BERYLLIUM OXIDE + MAGNESIUM OXIDE + ALUMINUM OXIDE

THERMAL LINEAR EXPANSION -- BERYLLIUM OXIDE + MAGNESIUM OXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	46-4	293-1158		4 MgO · 96 BeO · Al_2O_3; 90.12 BeO, 6.05 MgO, and 3.83 Al_2O_3; prepared from 97 pure MgO, 99.7 pure BeO, and 99+ pure Al_2O_3.	

TPRC

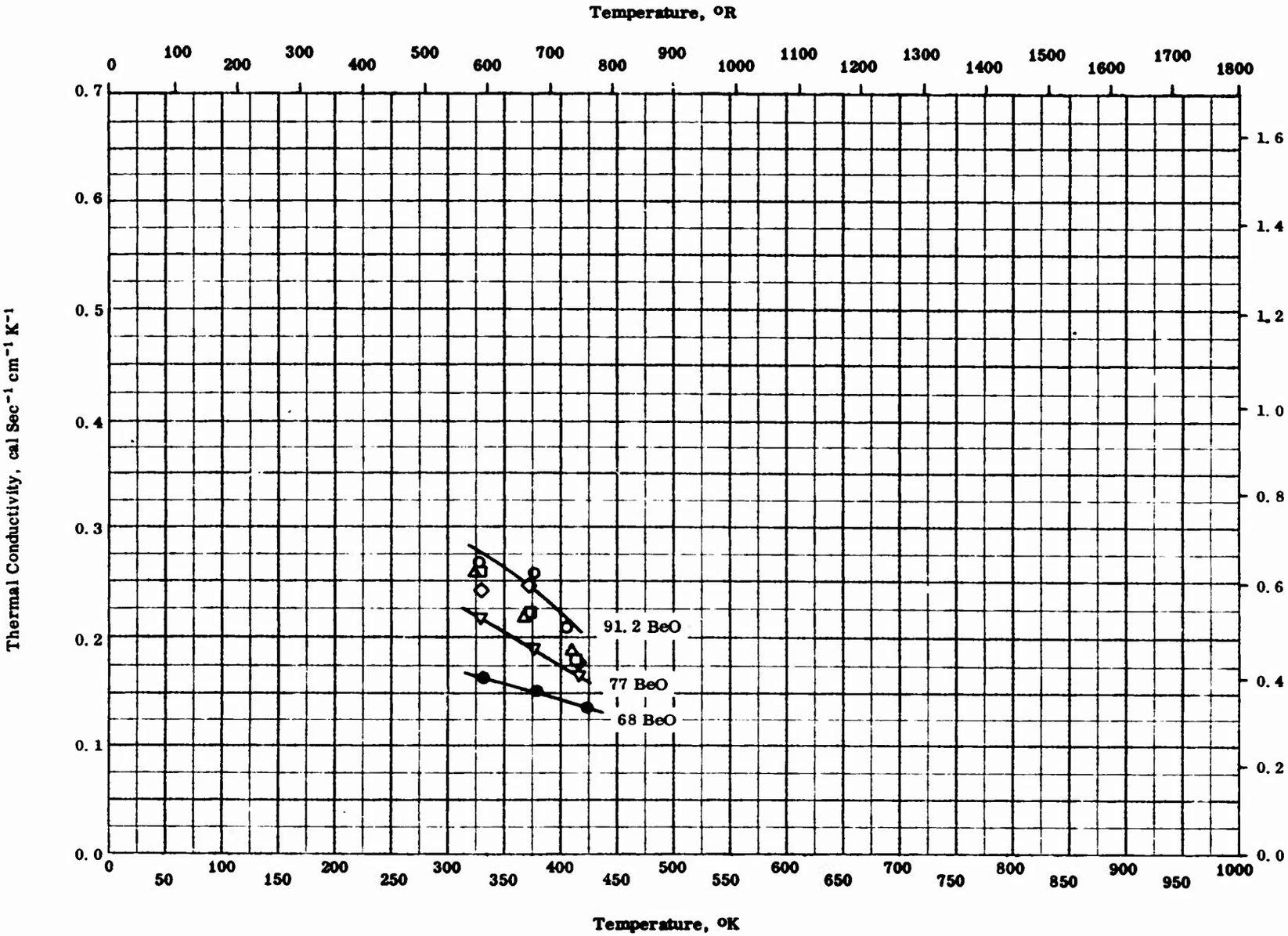


THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + MAGNESIUM OXIDE + ALUMINUM OXIDE + THORIUM DIOXIDE

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + MAGNESIUM OXIDE + + ALUMINUM OXIDE + THORIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◇	50-2	329-419		91.2 BeO, 4.0 MgO, 2.4 Al_2O_3, and 2.4 ThO_2; particle size passing -325 mesh for all raw materials. [Author's design.: A4].	Formed at a pressure of 10,000 lb in^{-2} and matured at 1600 C; crystalline phases of BeO, ThO_2, $MgO \cdot Al_2O_3$, MgO present.
○	50-2	329-418		87.4 BeO, 8.0 MgO, 2.3 Al_2O_3, and 2.3 ThO_2; same as above. [Author's design.: A4].	Same as above.
□	50-2	331-425		80.8 BeO, 15.0 MgO, 2.1 Al_2O_3, and 2.1 ThO_2; same as above. [Author's design.: A15].	Same as above.
△	50-2	329-415		82.8 BeO, 8.0 MgO, 4.6 Al_2O_3, and 4.6 ThO_2; same as above. [Author's design.: B8].	Same as above.
▽	50-2	327-414		76.5 BeO, 15.0 MgO, 4.25 Al_2O_3, and 4.25 ThO_2; same as above. [Author's design.: B15].	Same as above.
●	50-2	328-417		68.0 BeO, 15.0 MgO, 8.5 Al_2O_3, and 8.5 ThO_2; same as above. [Author's design.: C15].	Same as above.

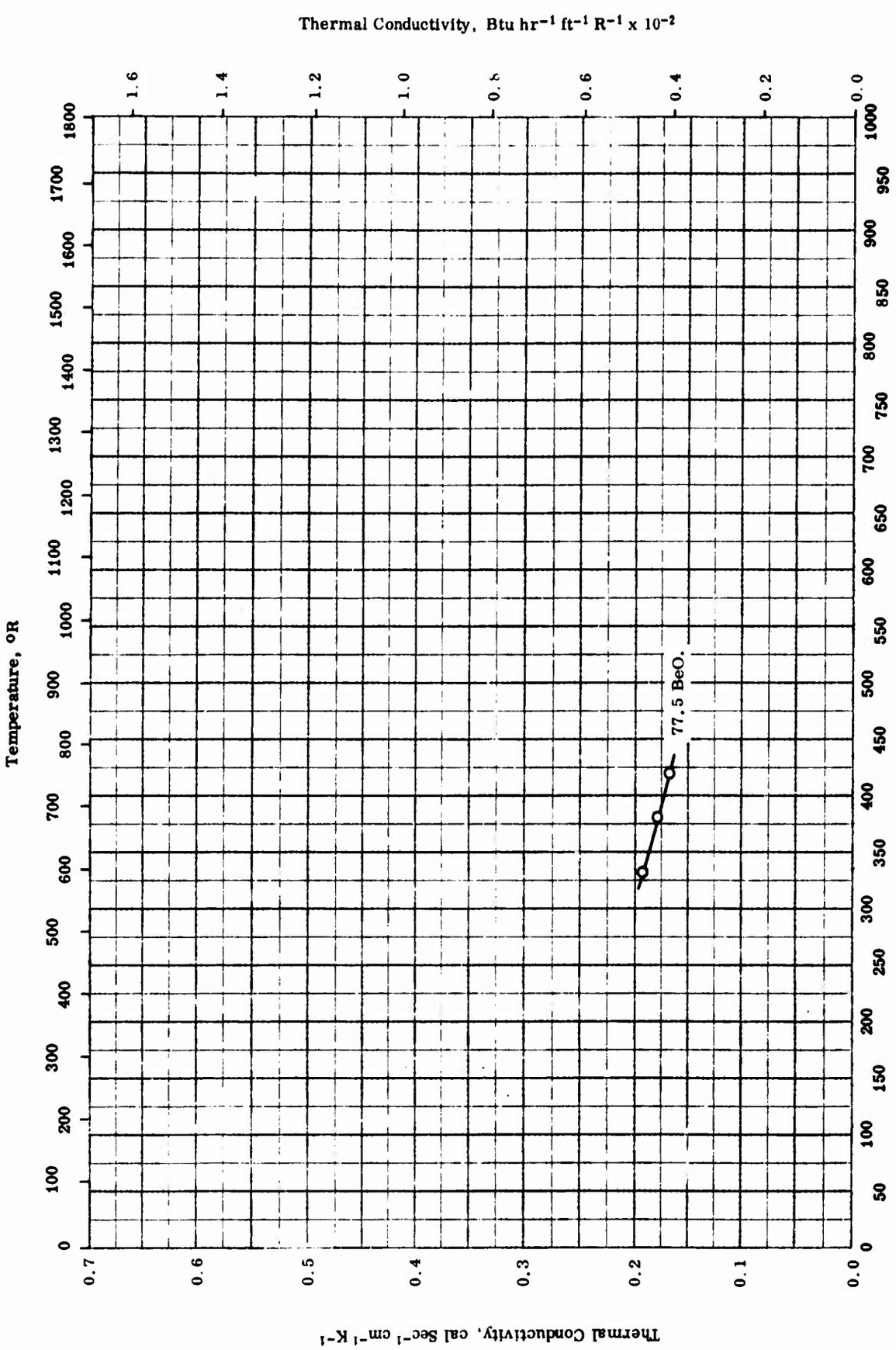


THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + MAGNESIUM OXIDE +
+ ALUMINUM OXIDE + ZIRCONIUM DIOXIDE

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + MAGNESIUM OXIDE + + ALUMINUM OXIDE + ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	50-2	327-404		91.2 BeO, 4.0 MgO, 2.4 Al_2O_3, and 2.4 ZrO_2; particle size passing -325 mesh for all raw materials. [Author's design.: N4].	Sample formed at a pressure of 10,000 psi and matured at 1500 C.
□	50-2	328-413		87.4 BeO, 8.0 MgO, 2.3 Al_2O_3, and 2.3 ZrO_2; same as above. [Author's design.: N8]	Same as above.
△	50-2	325-409		80.8 BeO, 15.0 MgO, 2.1 Al_2O_3, and 2.1 ZrO_2; same as above. [Author's design.: N15]	Same as above.
◇	50-2	329-414		82.8 BeO, 8.0 MgO, 4.6 Al_2O_3, and 4.6 ZrO_2; same as above. [Author's design.: O8]	Same as above.
▽	50-2	328-415		76.5 BeO, 15.0 MgO, 4.25 Al_2O_3, and 4.25 ZrO_2; same as above. [Author's design.: O15]	Same as above except matured at 1550 C.
●	50-2	331-423		68 BeO, 15 MgO, 8.5 Al_2O_3, and 8.5 ZrO_2; same as above. [Author's design.: P15]	Same as above.



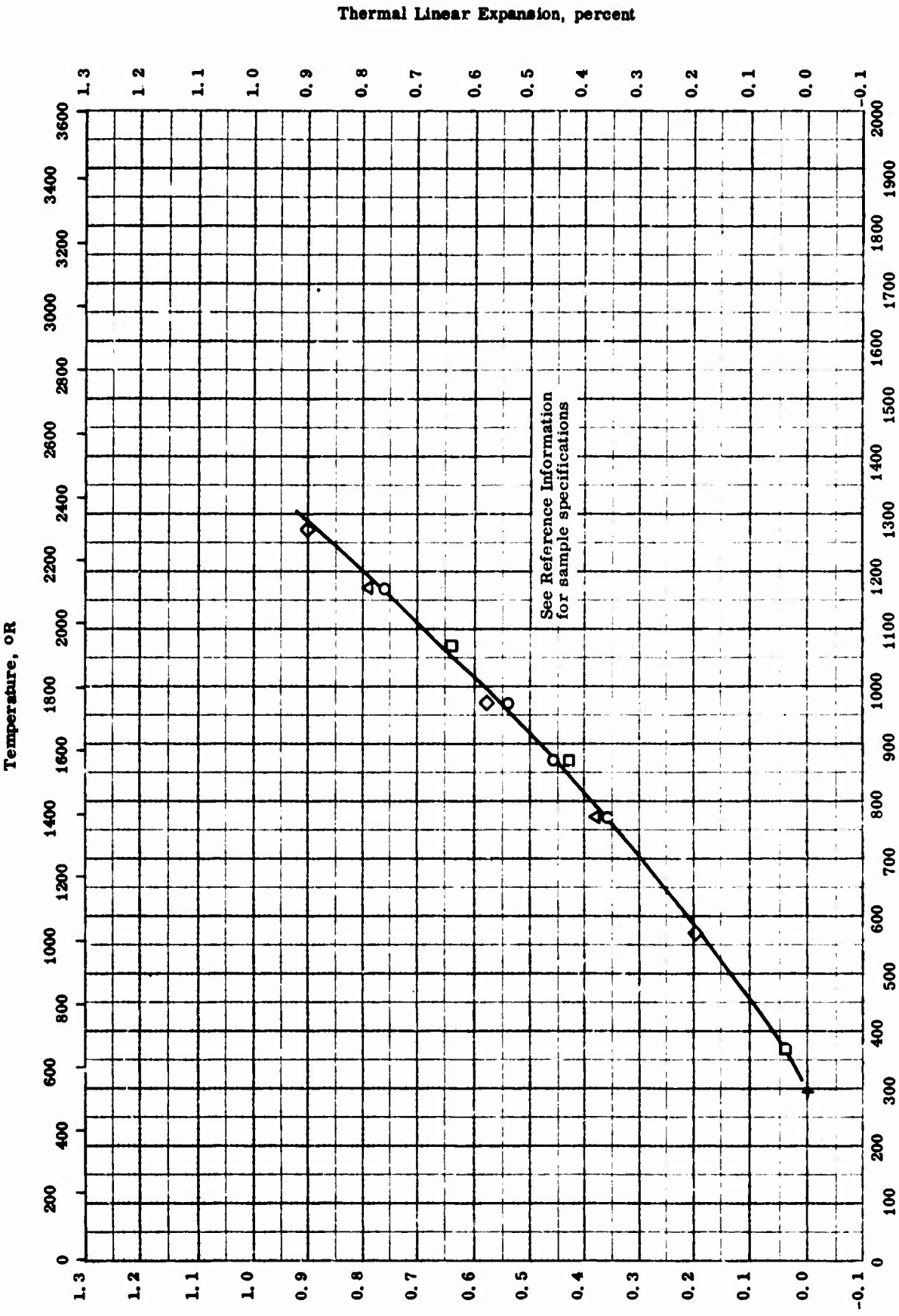
THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + MAGNESIUM OXIDE + ZIRCONIUM DIOXIDE + ALUMINUM OXIDE

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + MAGNESIUM OXIDE + + ZIRCONIUM DIOXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	50-2	332-420		77.5 BeO, 8.0 MgO, 8.0 ZrO_2, and 6.5 Al_2O_3; particle size passing -325 mesh for all materials. [Author's design.: Y8].	Formed at a pressure of 10,000 psi and matured at 1550 C; crystalline phases of BeO, ZrO_2, $BeO \cdot Al_2O_3$, and MgO present.

THERMAL LINEAR EXPANSION -- BERYLLIUM OXIDE + THORIUM DIOXIDE + ALUMINUM OXIDE



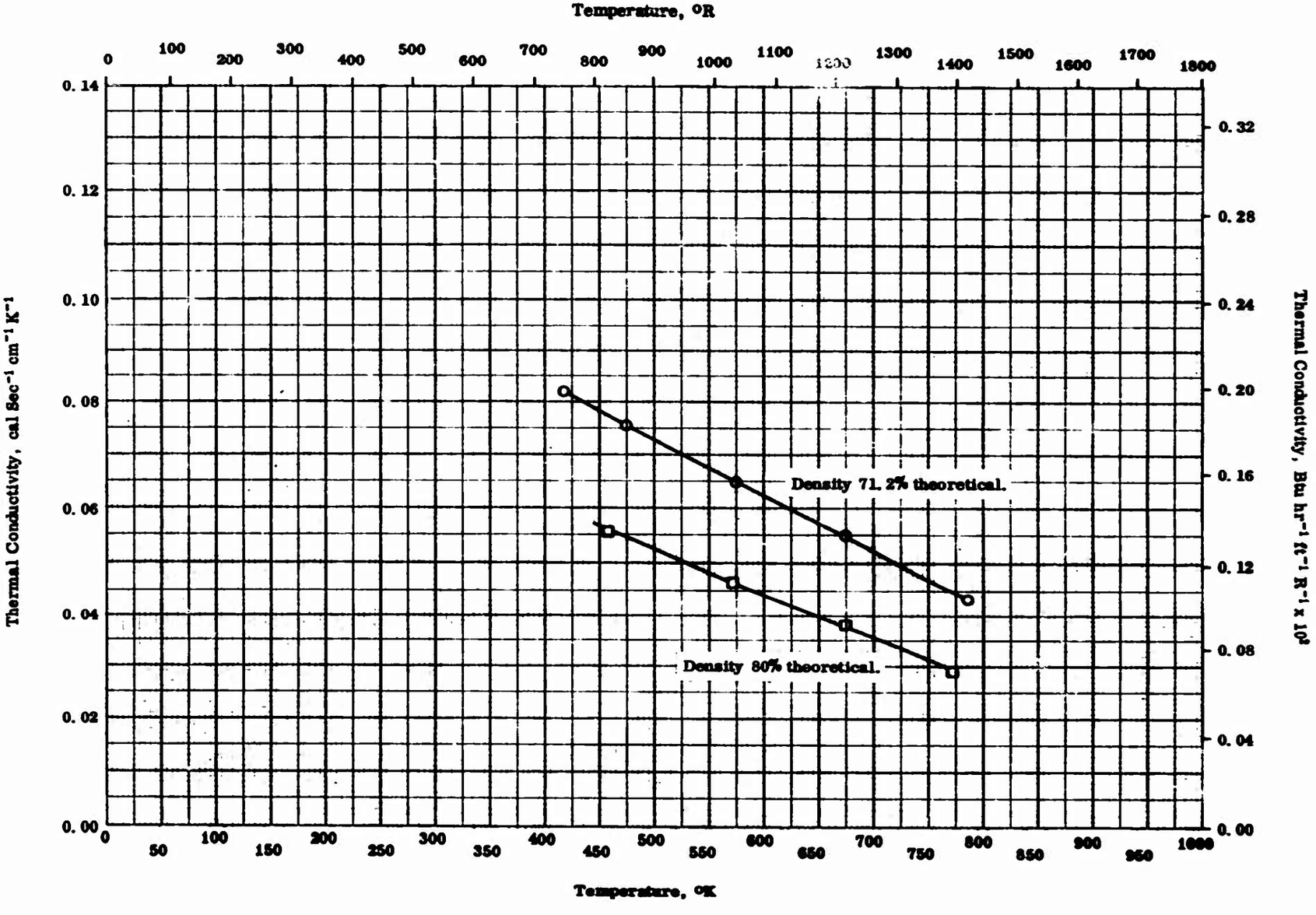
Thermal Linear Expansion, percent

THERMAL LINEAR EXPANSION -- BERYLLIUM OXIDE + THORIUM DIOXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	46-4	293-1173		160 BeO · 2 Al_2O_3 · ThO_2; 89.55 BeO, 5.91 ThO_2, and 4.56 Al_2O_3; prepared from 99.7 pure BeO, 99+ pure Al_2O_3, and 99+ pure ThO_2 (calcined).	
□	46-4	293-1074		48 BeO · Al_2O_3 · ThO_2; 76.63 BeO, 16.86 ThO_2, and 6.5 Al_2O_3; raw materials same as above.	
◇	46-4	293-1273		24 BeO · 2 Al_2O_3 · ThO_2; 56.19 BeO, 24.72 ThO_2, and 19.09 Al_2O_3; raw materials same as above.	
△	46-4	293-1173		12 BeO · Al_2O_3 · ThO_2; 45.05 BeO, 39.65 ThO_2, and 15.30 Al_2O_3; raw materials same as above.	

TPRC



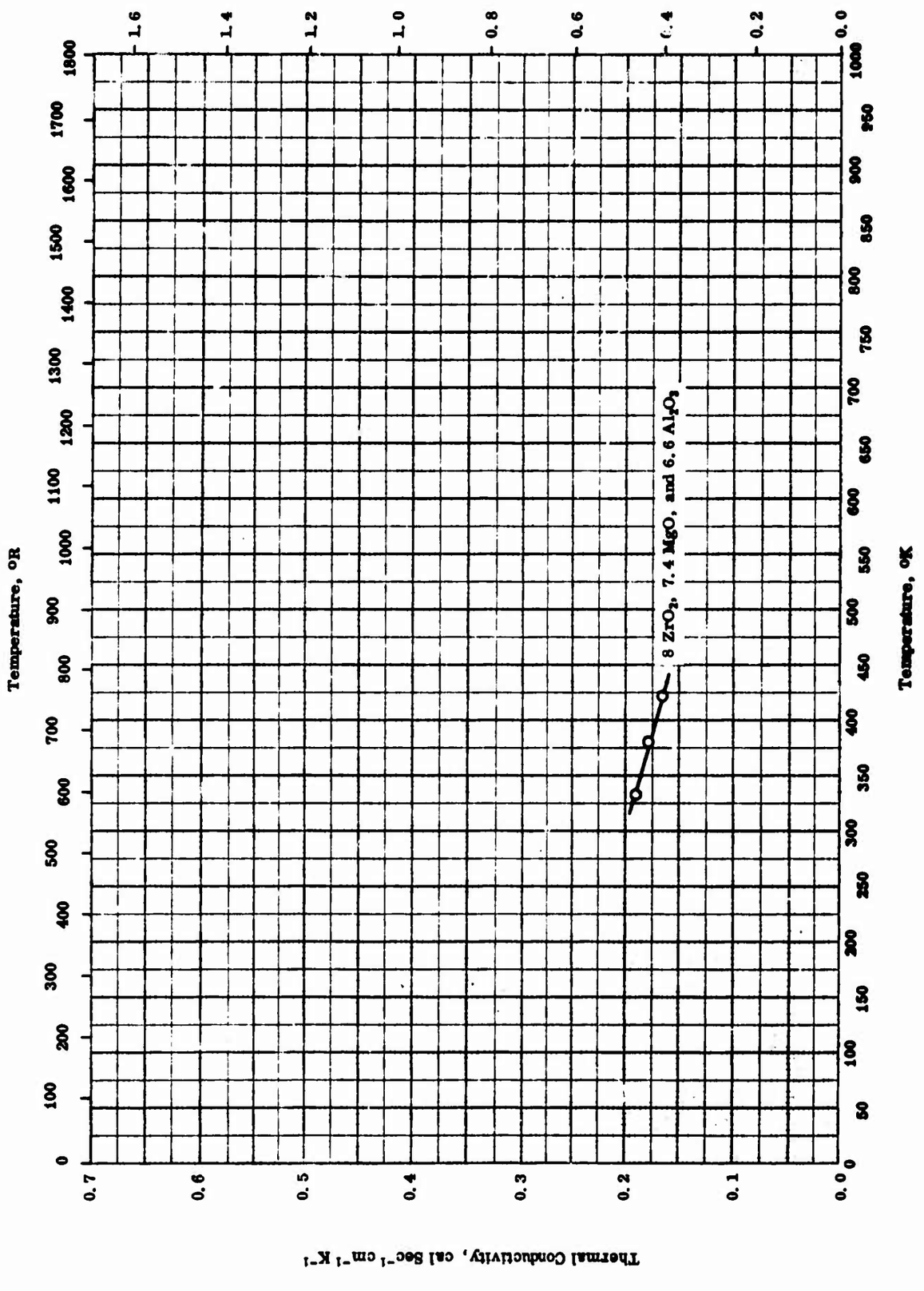
THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + URANIUM DIOXIDE

TPRC

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	57-3	413-783		53 BeO and 47 UO_2; density 71.2% theoretical.	Sintered.
□	57-3	458-733		53 BeO and 47 UO_2; density 80.0% theoretical.	Sintered.



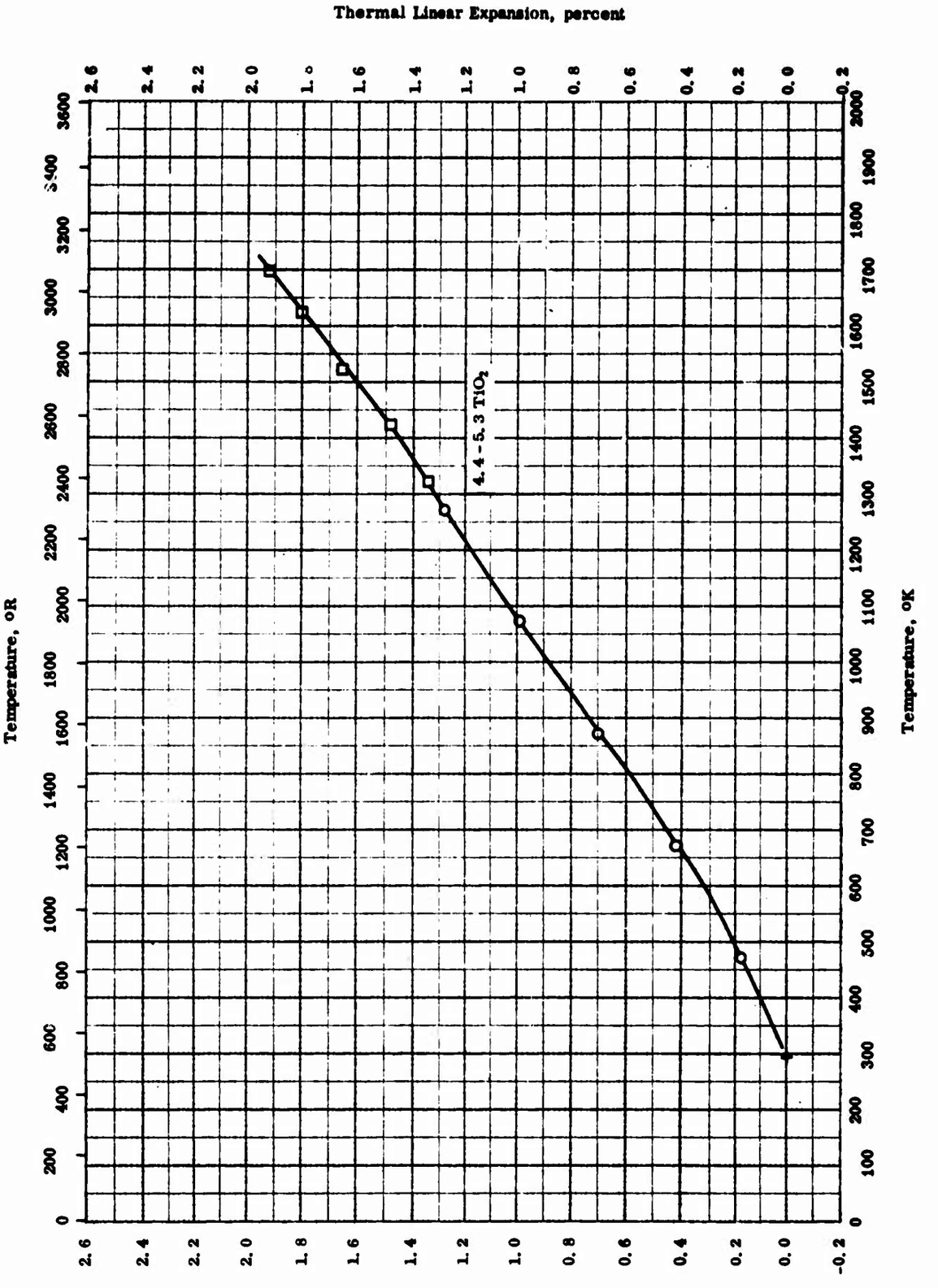
THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + ZIRCONIUM DIOXIDE + MAGNESIUM OXIDE + ALUMINUM OXIDE

THERMAL CONDUCTIVITY -- BERYLLIUM OXIDE + ZIRCONIUM DIOXIDE + + MAGNESIUM OXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	50-2	333-421		78 BeO, 8 ZrO_2, 7.4 MgO, 6.6 Al_2O_3.	Samples formed at 10,000 psi, and matured at 1600 C; all raw materials passed 325 mesh screen; crystalline phases of BeO, ZrO_2, $BeO \cdot Al_2O_3$ and MgO present.

TPRC



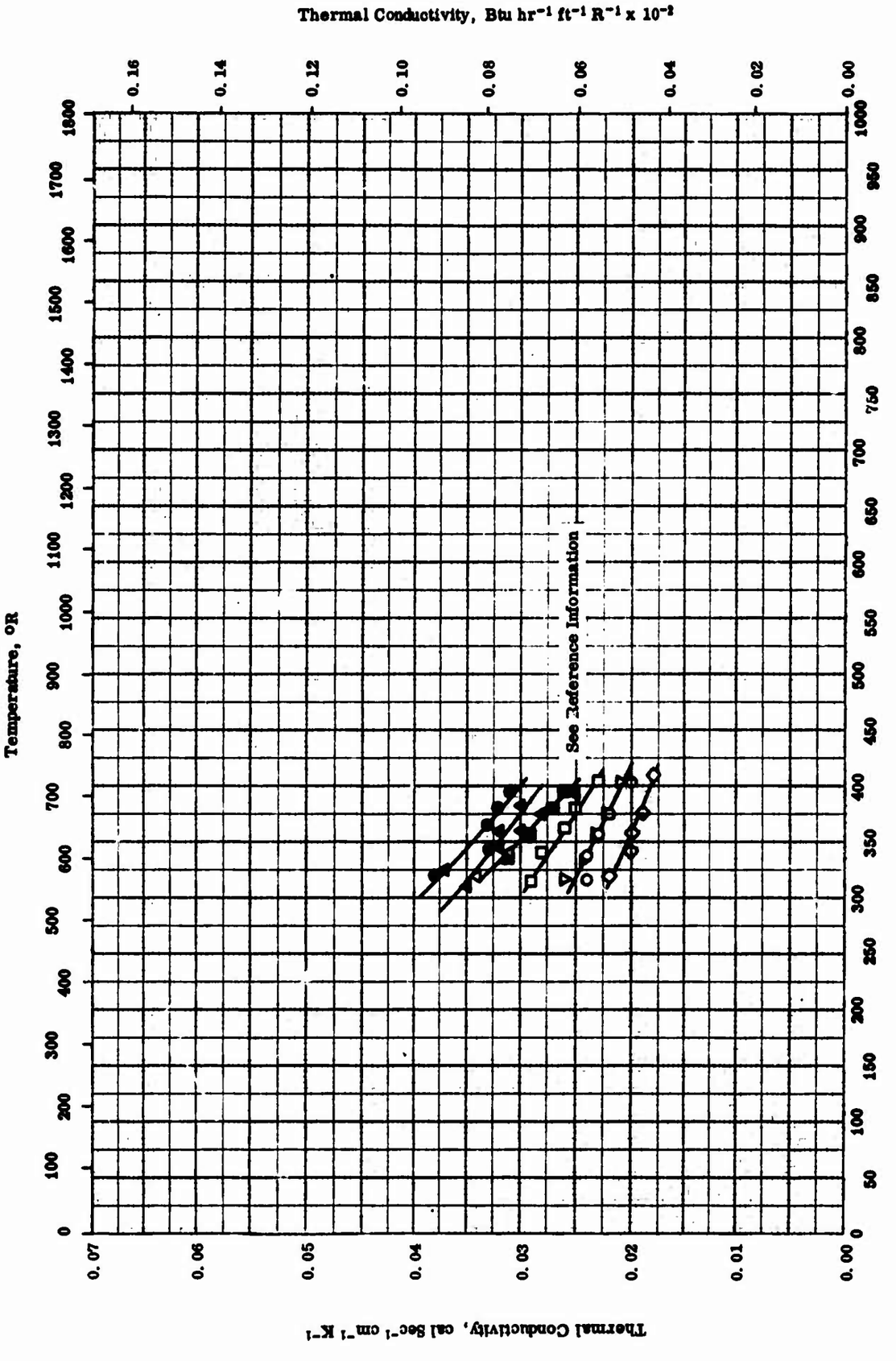
THERMAL LINEAR EXPANSION — CALCIUM OXIDE + TITANIUM DIOXIDE

THERMAL LINEAR EXPANSION -- CALCIUM OXIDE + TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-33	373-1273		Stabilized calcia; 94.72 CaO and 5.28 TiO_2.	Pressed and fired to 1700 C.
□	54-33	1273-1698		Stabilized calcia; 95.57 CaO and 4.43 TiO_2.	Same as above.

TPRC



THERMAL CONDUCTIVITY -- CERIUM DIOXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- CERIUM DIOXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-4	316-404		96 CeO_2 and 4 MgO; density 6.02 g cm^{-3} and water absorption 0%.	Fired at 2840 F; with buff color.
□	52-4	315-404		94 CeO_2 and 6 MgO density 5.58 g cm^{-3} and water absorption 0.95%.	Fired at 2780 F; with buff color.
▽	52-4	316-403		92 CeO_2 and 8 MgO; density 5.63 g cm^{-3} and water absorption 0.033%.	Fired at 2620 F; with buff color.
◇	52-4	319-410		92 CeO_2 and 8 MgO; density 5.82 g cm^{-3} and water absorption 0.21%.	Fired at 2780 F; with buff color.
△	52-4	319-394		90 CeO_2 and 10 MgO; density 4.59 g cm^{-3} and water absorption 0.34%.	Fired at 2700 F; with buff color.
●	52-4	320-396		90 CeO_2 and 10 MgO; density 4.68 g cm^{-3} and water absorption 0.136%.	Fired at 2725 F; with buff color.
■	52-4	319-395		80 CeO_2 and 20 MgO; density 4.94 g cm^{-3} and water absorption 0.054%.	Fired at 2700 F; with buff color.
▲	52-4	310-382		80 CeO_2 and 20 MgO; density 5.05 g cm^{-3} and water absorption 0.003%.	Fired at 2700 F; with buff color.

PROPERTIES OF CERIUM DIOXIDE + URANIUM OXIDES

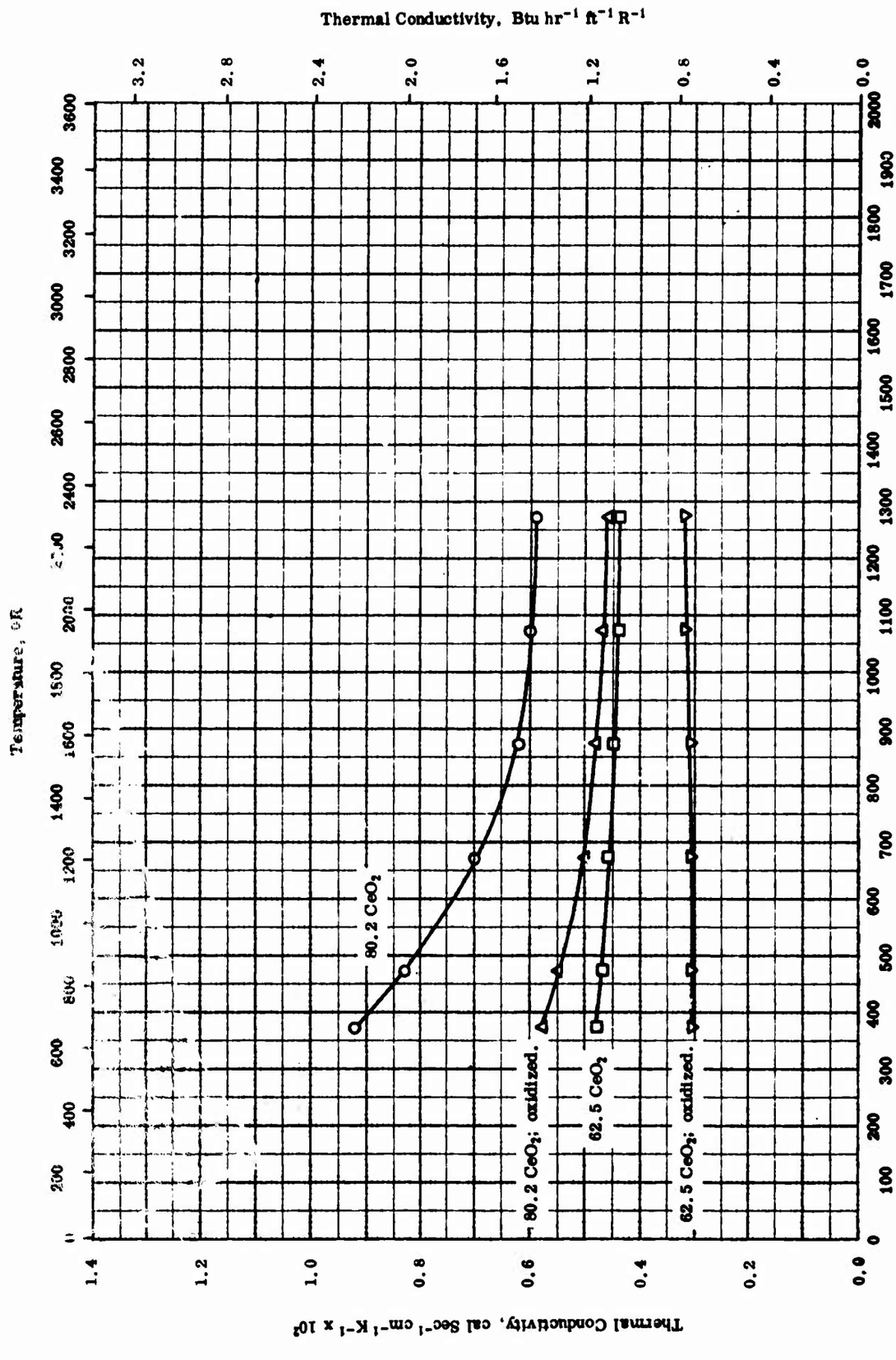
REPORTED VALUES

Density		g cm^{-3}	lb ft^{-3}
○	44.9 $UO_{2.67}$	8.30	518
□	43.6 UO_2	8.42	525
△	28.9 $UO_{2.67}$	8.03	501

PROPERTIES OF CERIUM DIOXIDE + URANIUM OXIDES

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Reqt. Error %	Sample Specifications	Remarks
O	58-27	298		55.1 CeO_2 and 44.9 $UO_{2.37}$.	
□	58-27	298		56.4 CeO_2 and 43.6 UO_2.	
△	58-27	298		71.1 CeO_2 and 28.9 $UO_{2.47}$.	



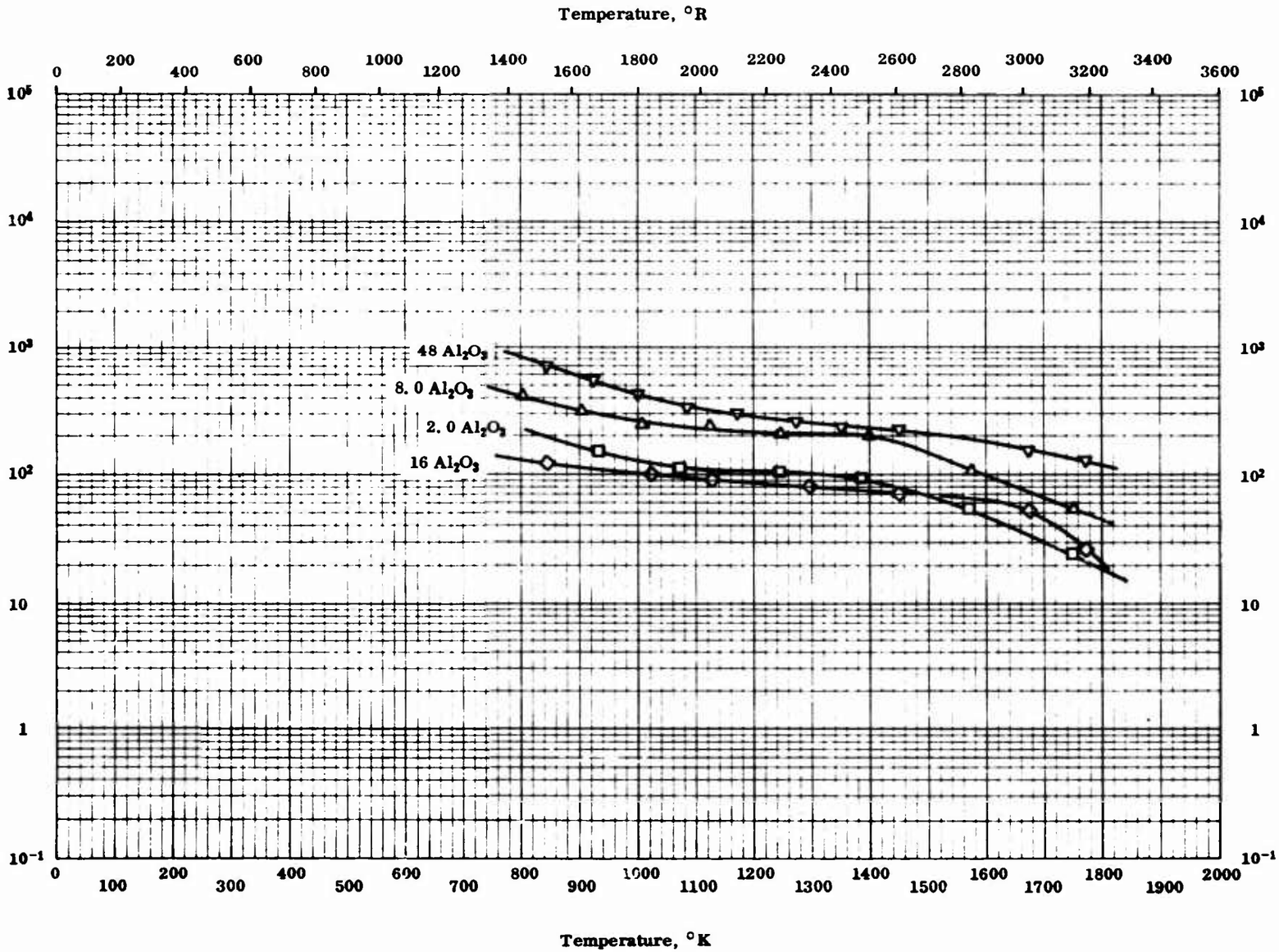
THERMAL CONDUCTIVITY -- CERIUM DIOXIDE + URANIUM DIOXIDE

THERMAL CONDUCTIVITY -- CERIUM DIOXIDE + URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	58-3	373-1273	<± 10	80.2 CeO_2 and 19.8 UO_2; single phase solid solution with bulk density 6.34 g cm^{-3}.	Dry-pressed from U_3O_8-CeO_2, fired in an oxidizing atmosphere to 1600 C for 1 hr and then machined.
△	58-3	373-1273	<± 10	Same as above.	Same as above except having been somewhat oxidized.
□	58-3	373-1273	<± 10	62.5 CeO_2 and 37.5 UO_2; single phase solid solution with bulk density 5.22 g cm^{-3}.	Dry-pressed from U_3O_8-CeO_2, fired in an oxidizing atmosphere to 1600 C for 1 hr, and then machined.
▽	58-3	373-1273	<± 10	Same as above.	Same as above except having been somewhat oxidized.

TPRC



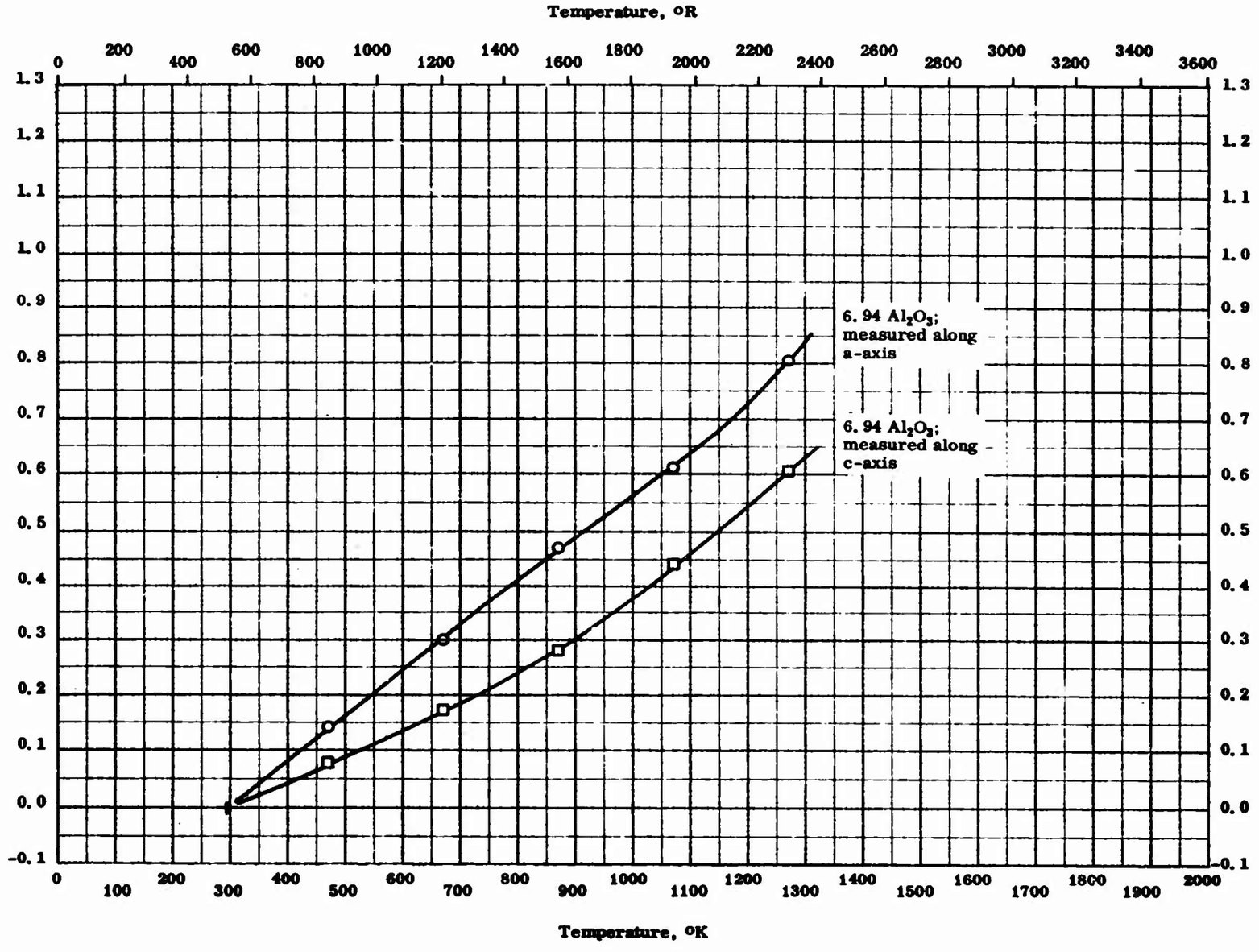
TPRC

ELECTRICAL RESISTIVITY -- CHROMIUM SESQUIOXIDE + ALUMINUM OXIDE

ELECTRICAL RESISTIVITY -- CHROMIUM SESQUIOXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	53-17	933-1753		98 Cr_2O_3 and 2 Al_2O_3.	Fired 10 hrs to 1500 C; poorly sintered.
△	53-17	803-1753		92 Cr_2O_3 and 8 Al_2O_3.	Same as above.
◇	53-17	843-1773		84 Cr_2O_3 and 16 Al_2O_3.	Same as above.
▽	53-17	843-1773		52 Cr_2O_3 and 48 Al_2O_3.	Same as above.



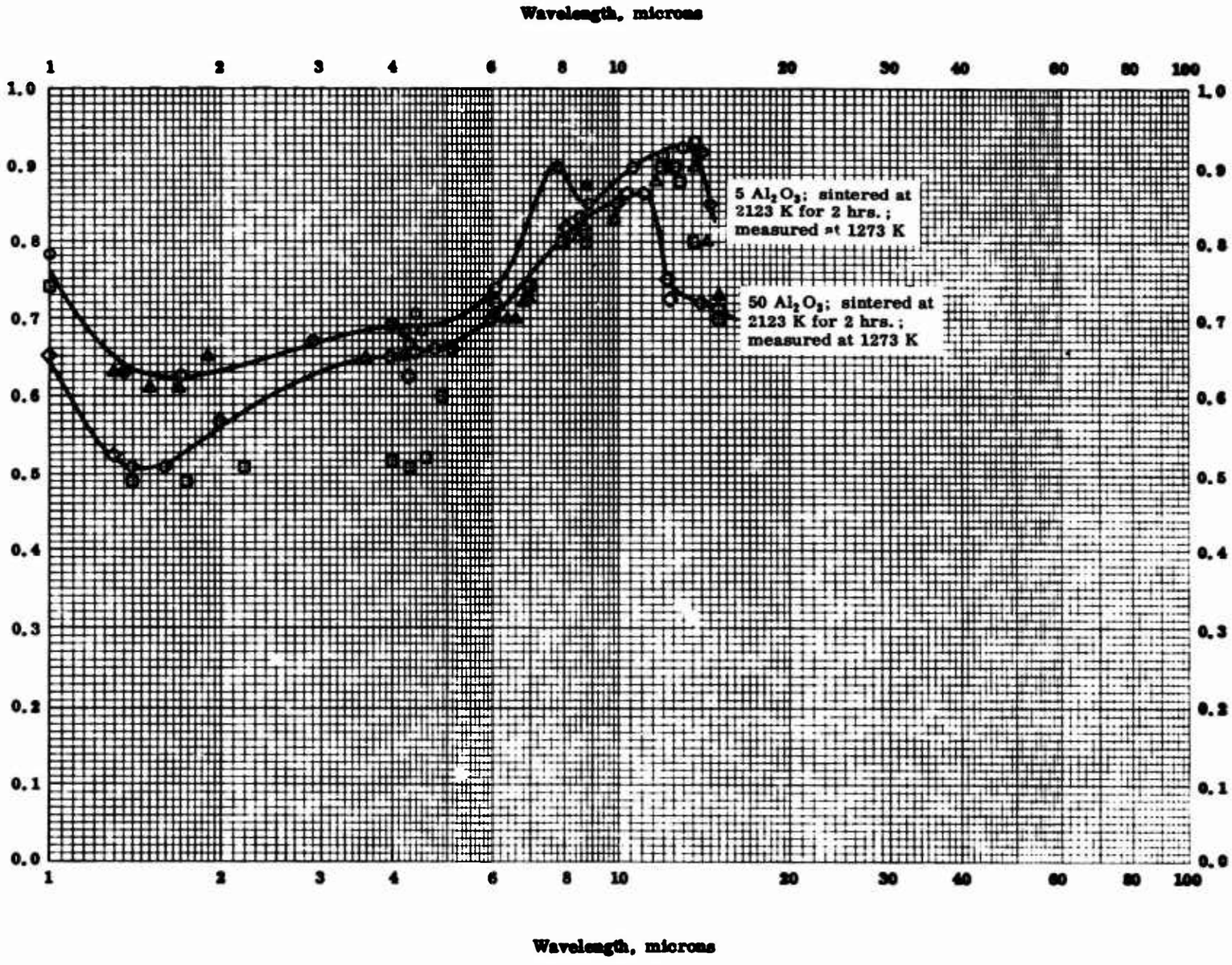
THERMAL LINEAR EXPANSION -- CHROMIUM SESQUIOXIDE + ALUMINUM OXIDE

THERMAL LINEAR EXPANSION -- CHROMIUM SESQUIOXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	60-36	299-1273		93.06 Cr_2O_3 and 6.94 Al_2O_3.	Prepared by ball-milling Cr_2O_3 and Al_2O_3 for 4 hrs, passed through a 4 mesh standard screen, mixed with 15% binder (40 g Carbowax 20 M, 20 cc of 2% Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired to 1500 C for 17 hrs, cooled to room temperature in less than 30 min, and crushed to -325 mesh; measured along a-axis by x-ray diffraction.
□	60-36	299-1273		Same as above.	Same as above except measured along c-axis.

TPRC

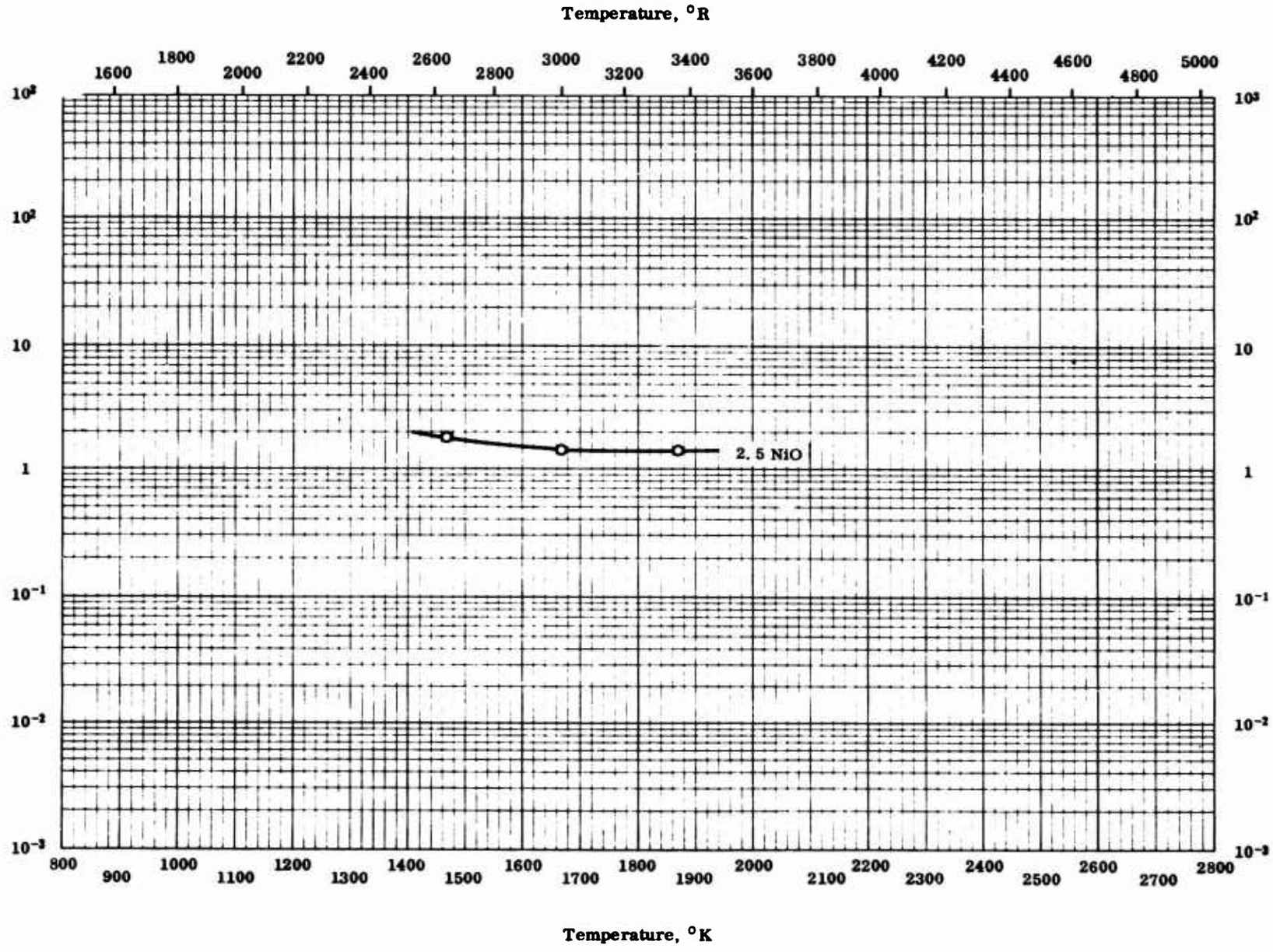


NORMAL SPECTRAL EMITTANCE -- CHROMIUM SESQUIOXIDE + ALUMINUM OXIDE

NORMAL SPECTRAL EMITTANCE -- CHROMIUM SESQUIOXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
◇	62-23	1273	1-15		50 Cr_2O_3 and 50 Al_2O_3; 0.038 in. thickness plate.	Sintered at 2123 K for 2 hrs; measured in air.
□	62-23	1273	1-15		70 Cr_2O_3 and 30 Al_2O_3; 0.042 in. thickness plate.	Same as above.
△	62-23	1273	1-15		90 Cr_2O_3 and 10 Al_2O_3; 0.043 in. thickness plate.	Same as above.
○	62-23	1273	1-15		95 Cr_2O_3 and 5 Al_2O_3; 0.036 in. thickness plate.	Same as above.



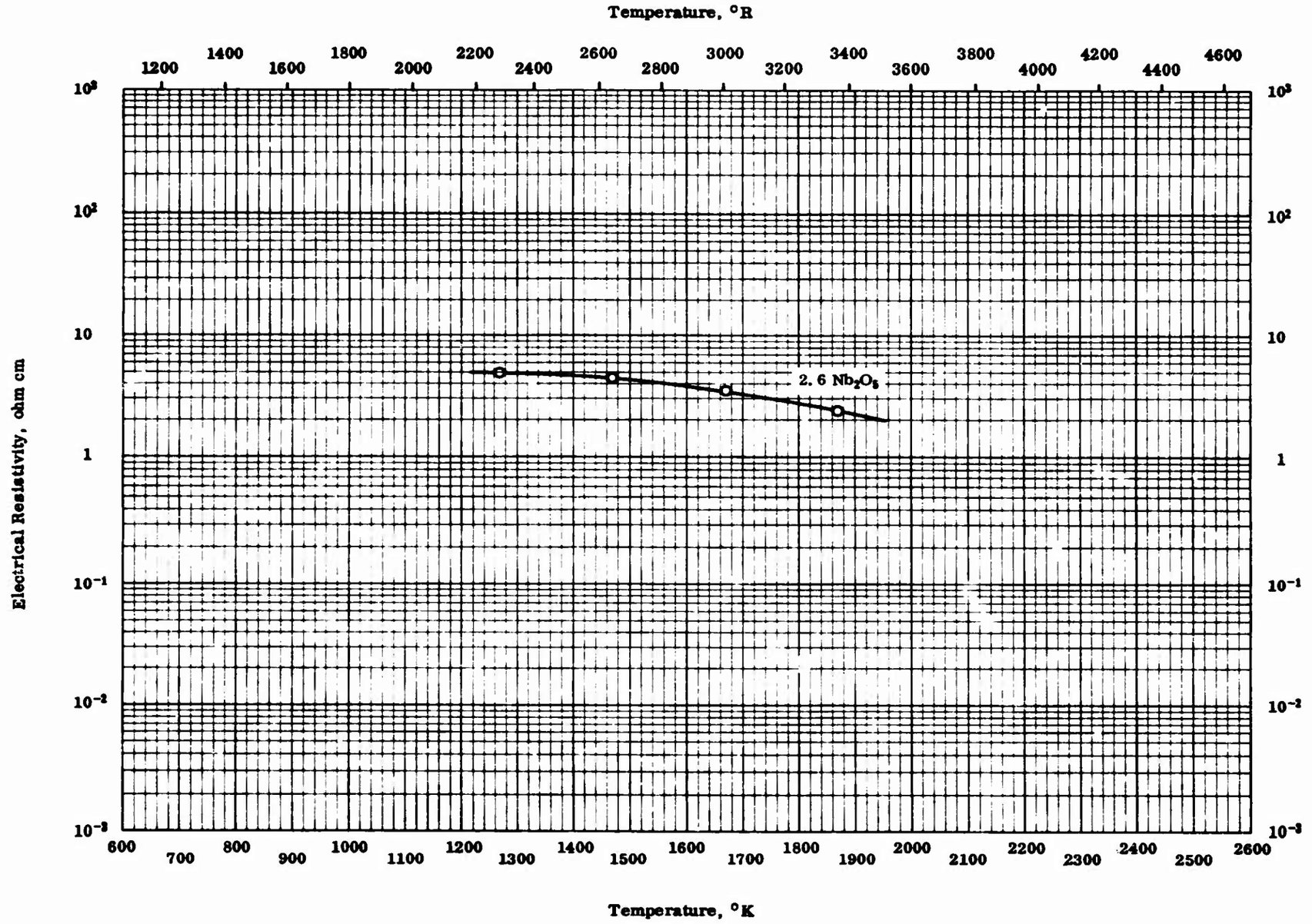
ELECTRICAL RESISTIVITY -- CHROMIUM SESQUIOXIDE + NICKEL MONOXIDE

ELECTRICAL RESISTIVITY -- CHROMIUM SESQUIOXIDE + NICKEL MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-16	1473-1873		Water free; 2.5 NiO, 0.5 alkalies, 0.055 Fe, 0.037 Ca, 0.023 Mg, 0.010 Si, and no trace of Al.	Presintered 1 hr at 1500 C in A atm.; results independent of frequency.

TPRC



TPRC

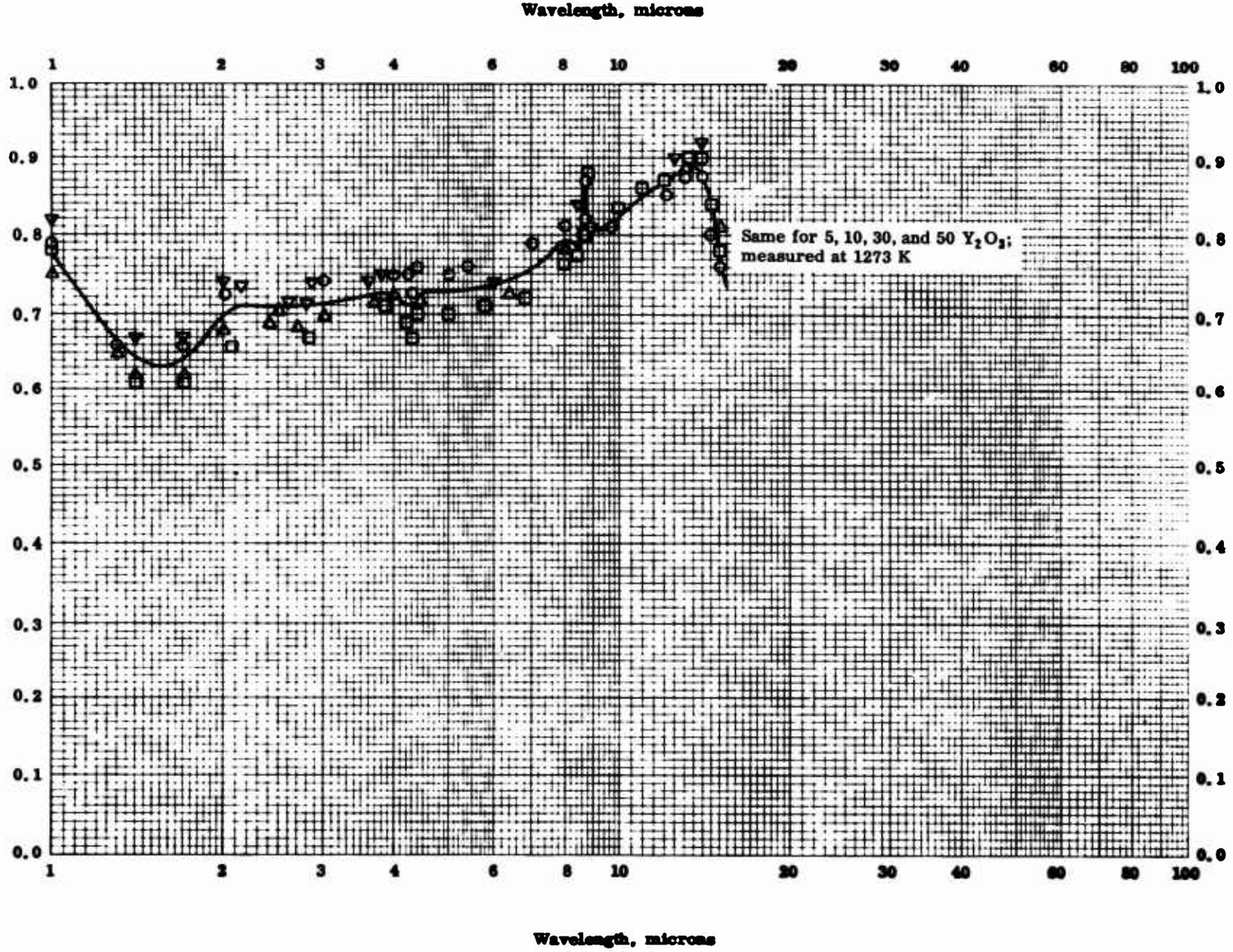
ELECTRICAL RESISTIVITY -- CHROMIUM SESQUIOXIDE + NIOBIUM PENTOXIDE

ELECTRICAL RESISTIVITY -- CHROMIUM SESQUIOXIDE + NIOBIUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-16	1273-1873		Water free; 2.6 Nb_2O_5, 0.5 Alkalies, 0.055 Fe, 0.037 Ca, 0.023 Mg, 0.010 Si, and no traces of Al.	Presintered 1 hr at 1500 in A atmos.; results independent of frequency.

TPRC



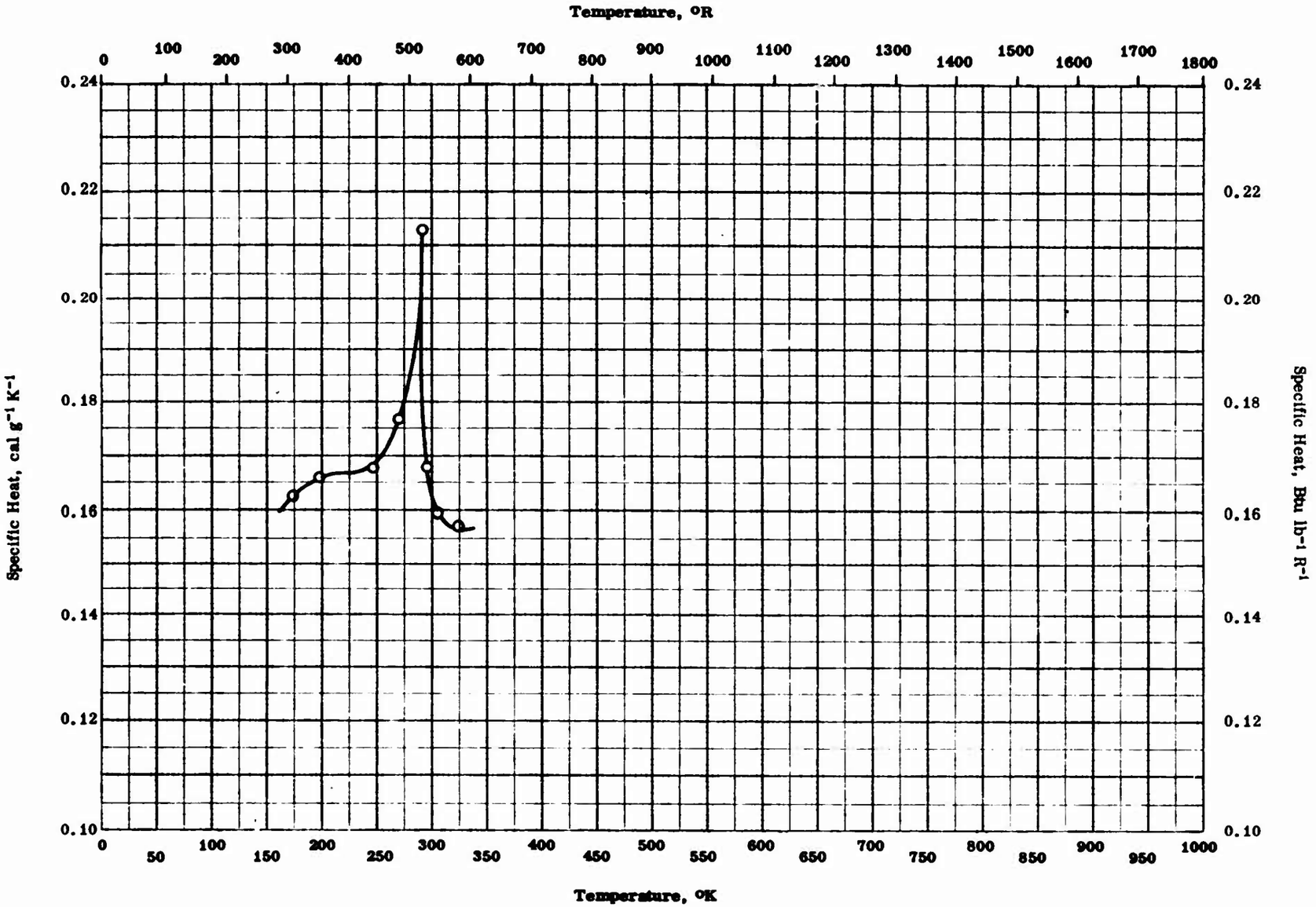
NORMAL SPECTRAL EMITTANCE -- CHROMIUM SESQUIOXIDE + YTTRIUM OXIDE

NORMAL SPECTRAL EMITTANCE -- CHROMIUM SESQUIOXIDE + YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. ° K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	62-23	1273	1-15		50 Cr_2O_3 and 50 Y_2O_3, 0.046 in. thickness plate.	Sintered at 2123 K for 2 hrs; measured in air; data taken from a curve.
□	62-23	1273	1-15		70 Cr_2O_3 and 30 Y_2O_3, 0.032 in. thickness plate.	Same as above.
△	62-23	1273	1-15		90 Cr_2O_3 and 10 Y_2O_3, 0.044 in. thickness plate.	Same as above except sintered at 2073 K for 2 hrs.
▽	62-23	1273	1-15		95 Cr_2O_3 and 5 Y_2O_3, 0.042 in. thickness plate.	Same as above.

TPRC



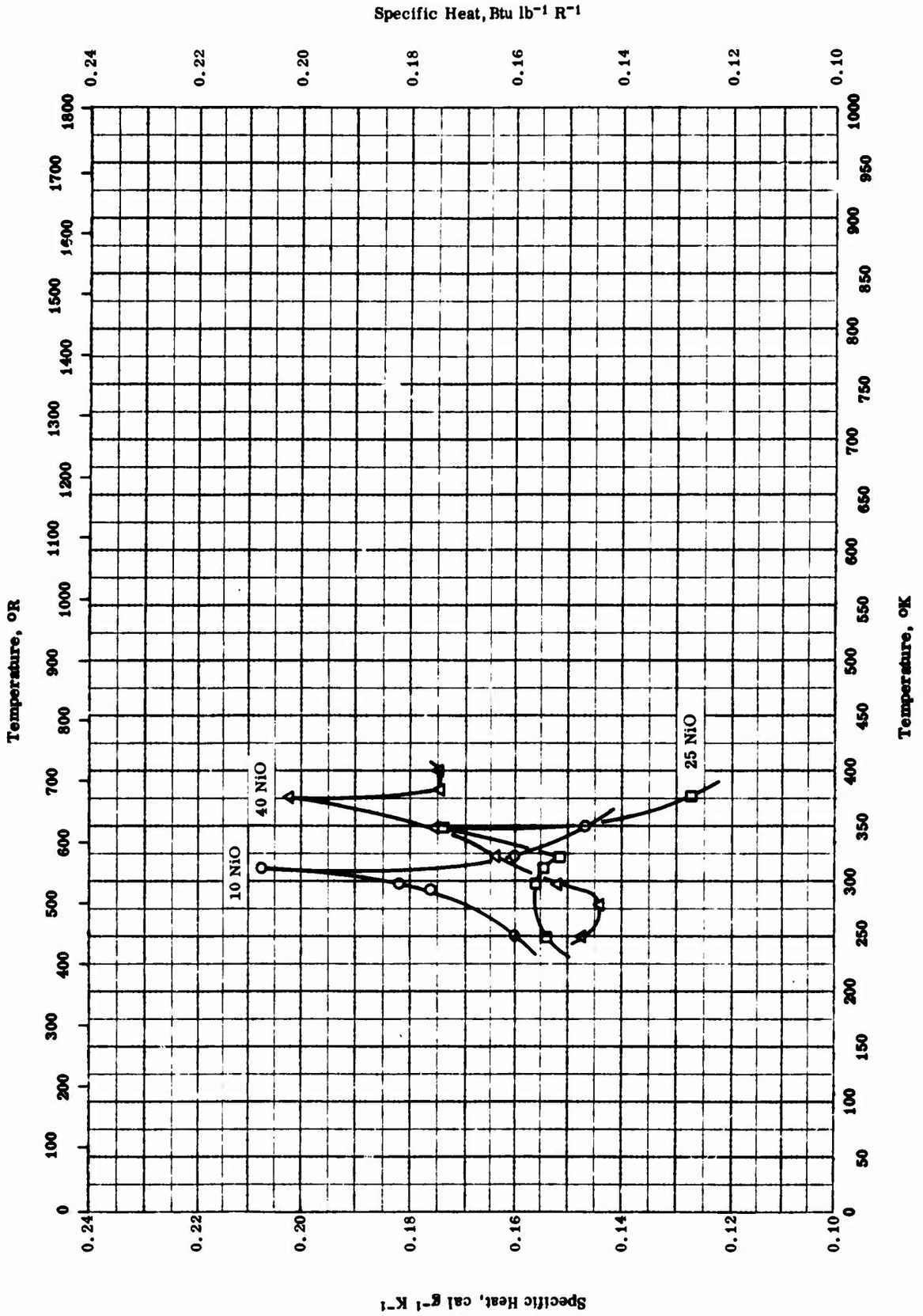
SPECIFIC HEAT -- COBALT (OUS) OXIDE + COPPER (IC) OXIDE

SPECIFIC HEAT -- COBALT (OUS) OXIDE + COPPER (IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-15	175-325		Inverse spinel; 91.24 CoO and 8.76 CuO.	Corresponding to 91.7 mole % CoO and 8.3 mole % CuO.

TPRC



SPECIFIC HEAT -- COBALT (OUS) OXIDE + NICKEL MONOXIDE

SPECIFIC HEAT -- COBALT (OUS) OXIDE + NICKEL MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-15	250-350		Inverse spinel; 90.03 CoO and 9.97 NiO.	Corresponding to 90 mole % CoO and 10 mole % NiO.
□	54-15	250-377		Inverse spinel; 75.06 CoO and 24.94 NiO.	Corresponding to 75 mole % CoO and 25 mole % NiO.
△	54-15	250-400		Inverse spinel; 59.98 CoO and 40.02 NiO.	Corresponding to 59.9 mole % CoO and 40.1 mole % NiO.

TPRC

Thermal Linear Expansion, percent

THERMAL LINEAR EXPANSION -- DYSPROSIUM OXIDE + CERIUM DIOXIDE

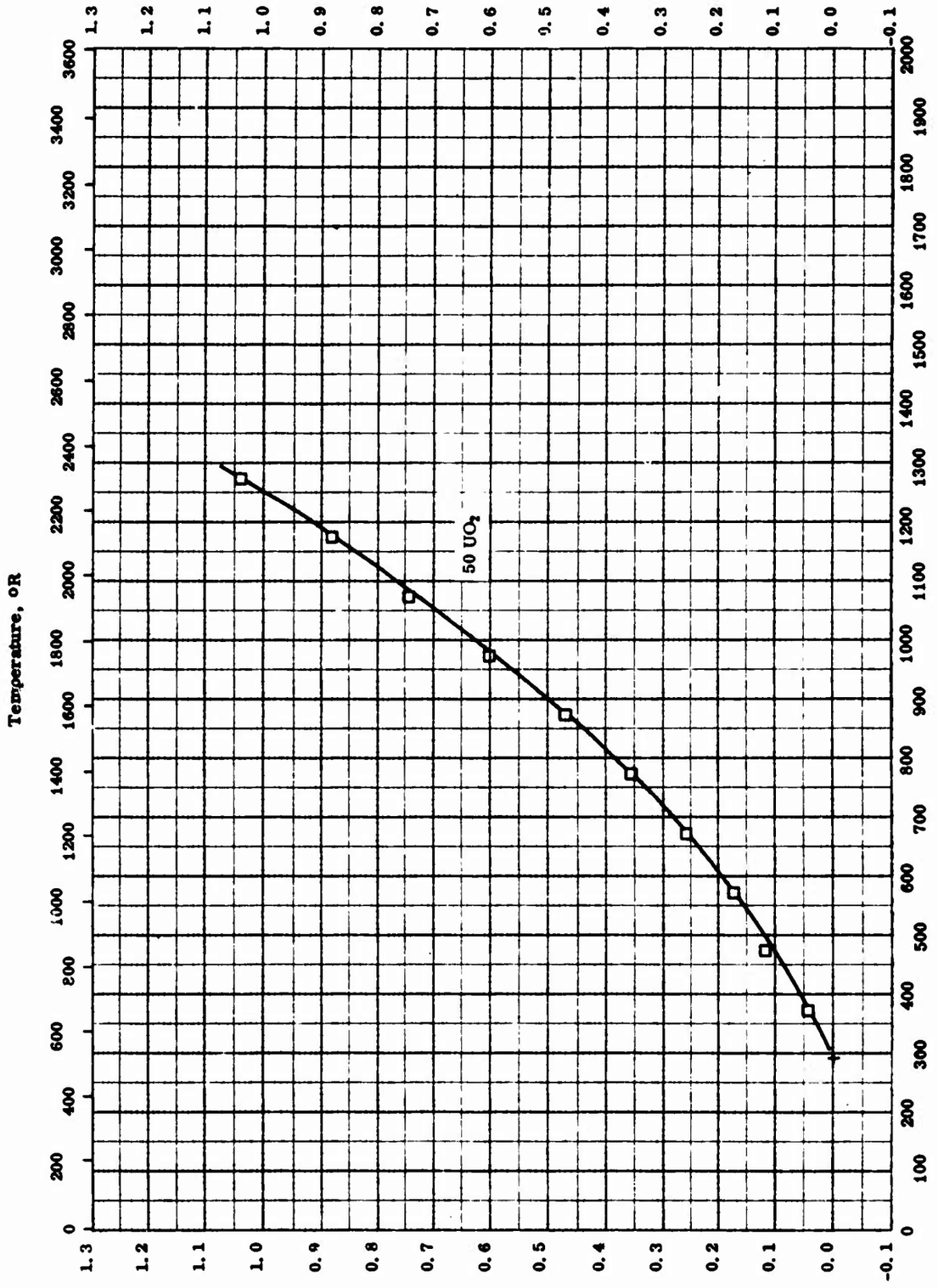
Thermal Linear Expansion, percent

THERMAL LINEAR EXPANSION -- DYSPROSIUM OXIDE + CERIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
Δ	60-38	303-1273		53.2 Dy_2O_3 and 46.8 CeO_2; solid solution of body centered cubic and face centered cubic phases.	Wet ball milled with flint pebbles for 2 hrs, dry pressed at 20,000 psi with 2% soluble wax emulsion into pellets 1/2 in. diameter by 1 in. long, and fired at 1600 C for 1 hr in air atm.

TPRC



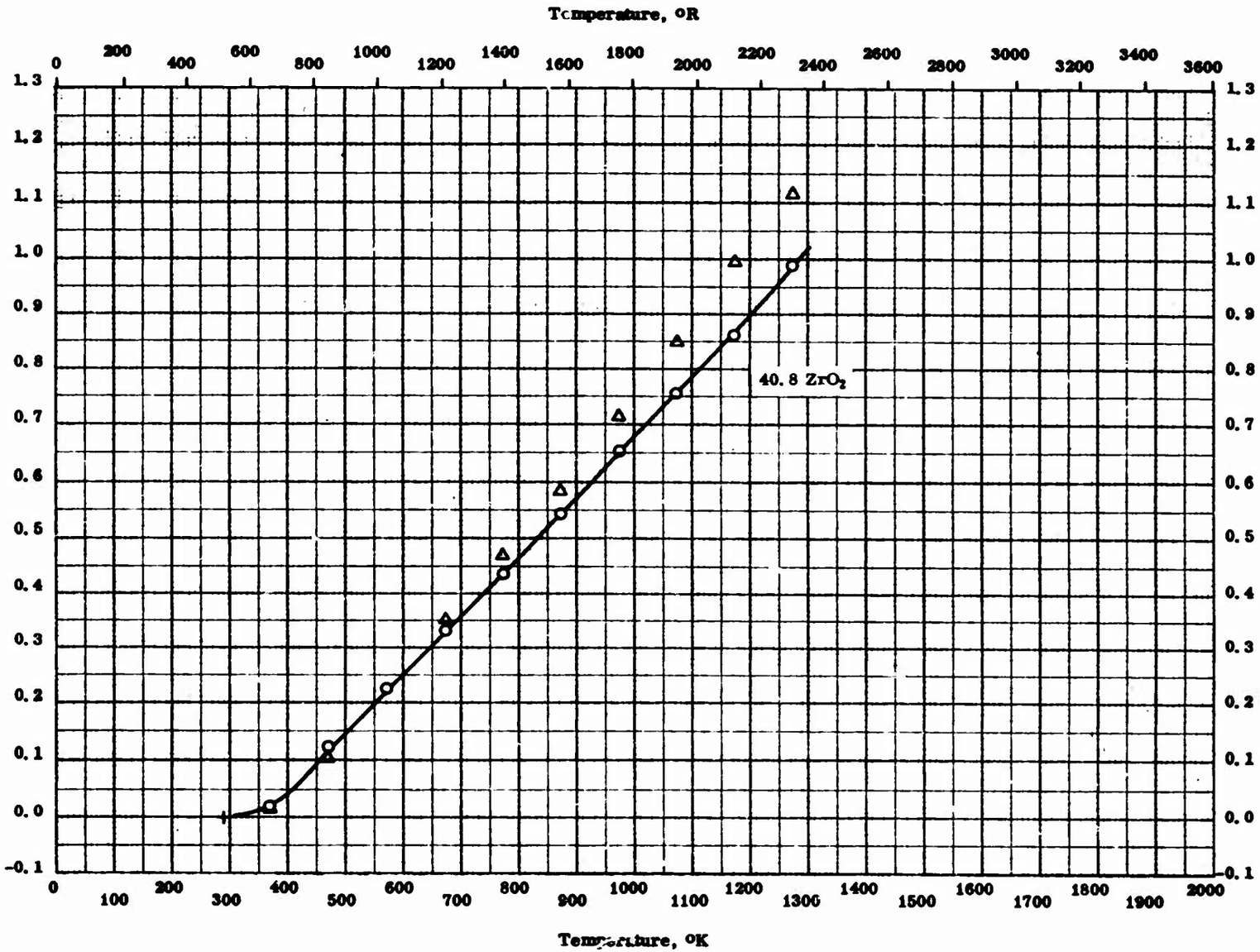
THERMAL LINEAR EXPANSION -- DYSPROSIUM OXIDE + URANIUM DIOXIDE

THERMAL LINEAR EXPANSION -- DYSPROSIUM OXIDE + URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	60-38	303-1273		50.0 Dy_2O_3 and 50.0 UO_2; one-phase face-centered cubic solid solution.	Wet ball milled with flint pebbles for 2 hrs, dry pressed at 20,000 psi with 2% soluble wax emulsion into pellets 1/2 in. diameter by 1 in. long, and fired for 1 hr.

TPRC

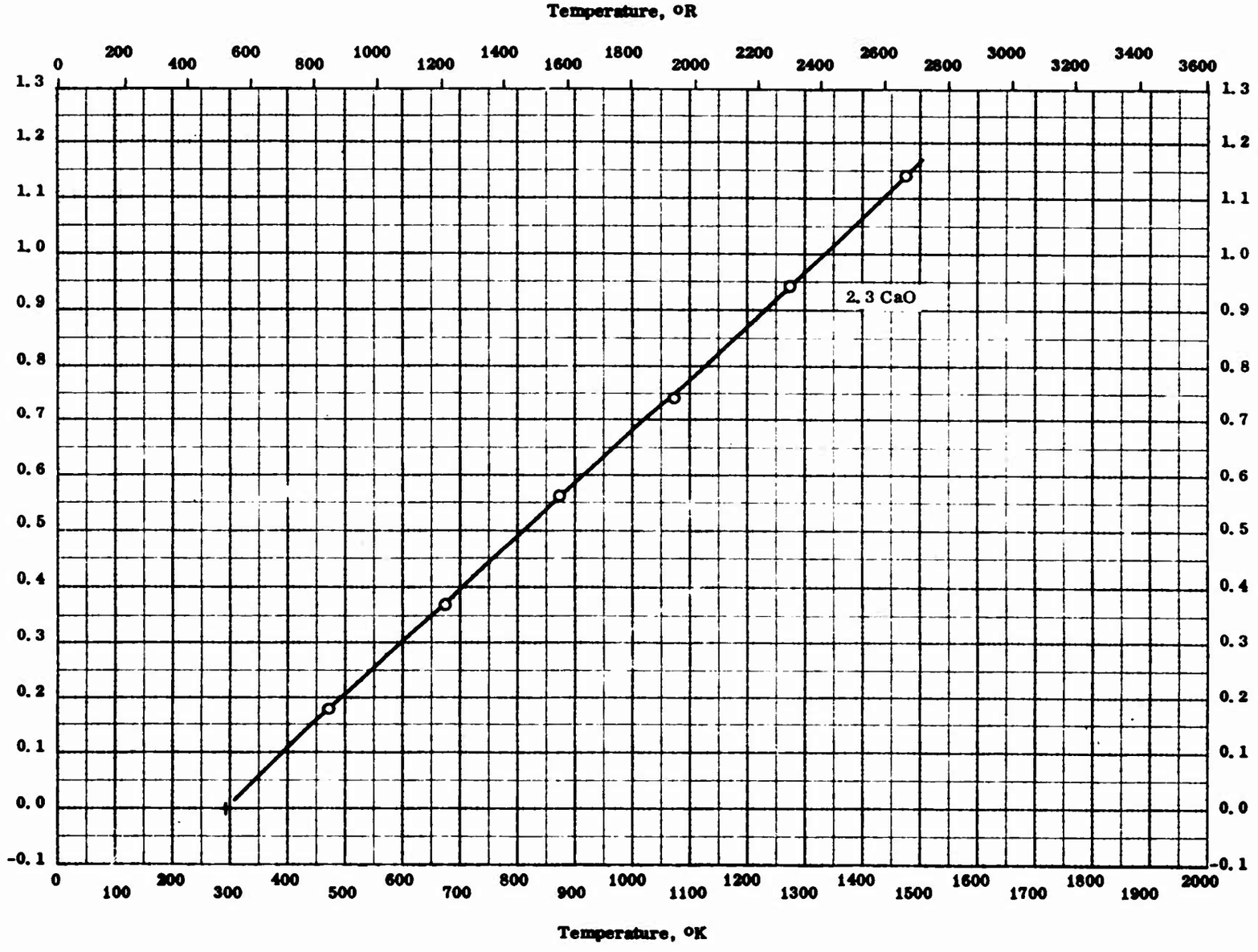


THERMAL LINEAR EXPANSION -- DYSPROSIUM OXIDE + ZIRCONIUM DIOXIDE

THERMAL LINEAR EXPANSION -- DYSPROSIUM OXIDE + ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	60-38	303-1273		59.2 Dy_2O_3 and 40.8 ZrO_2; one-phase face-centered cubic solid solution.	Wet ball mixed with flint pebbles for 2 hrs, dry pressed at 20,000 psi with 2% soluble wax emulsion into pellets 1/2 in. diameter by 1 in. long, and fired in H_2 atm for 1 hr.
△	60-38	303-1273		Same as above.	Same as above.

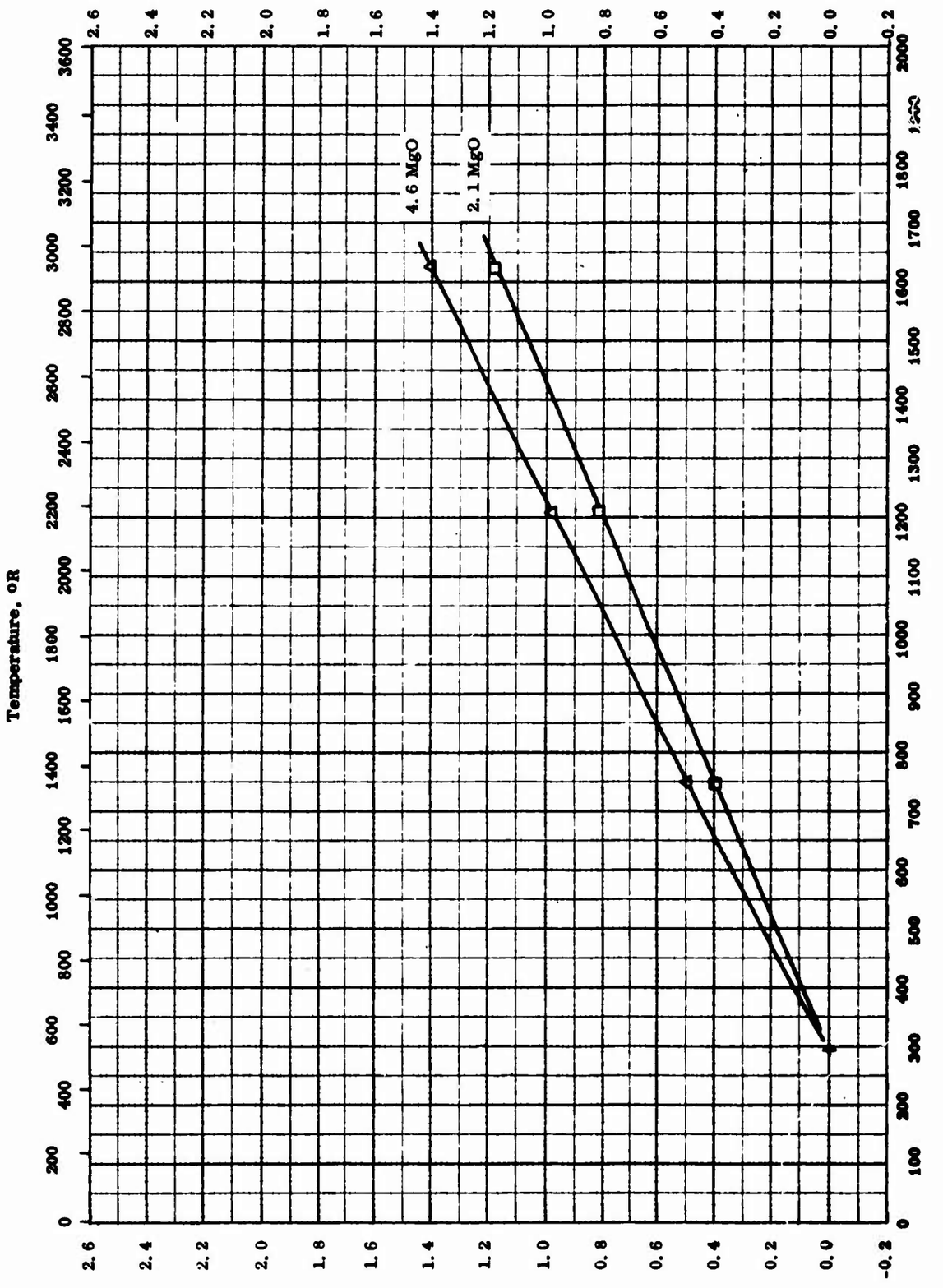


THERMAL LINEAR EXPANSION -- HAFNIUM DIOXIDE + CALCIUM OXIDE

THERMAL LINEAR EXPANSION -- HAFNIUM DIOXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-18	293-1473		97.7 HfO_2 and 2.3 CaO; density 524 lb ft^{-3}; porosity 10%.	Corresponding to 92 mole % HfO_2 and 8 mole % CaO; mixed, pressed at 20,000 psi, and soaked 2 hrs at 1650 C.

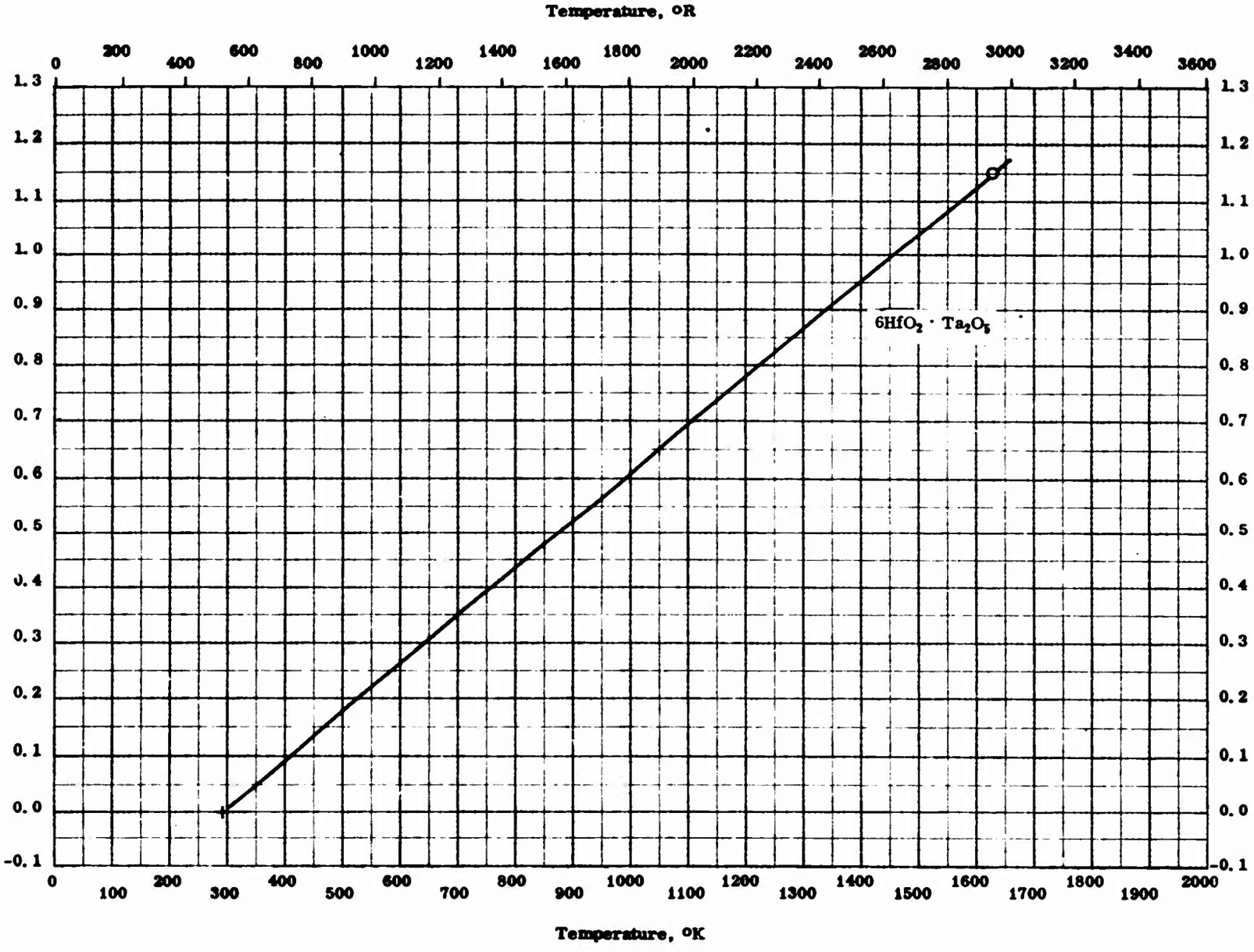


THERMAL LINEAR EXPANSION -- HAFNIUM DIOXIDE + MAGNESIUM OXIDE

THERMAL LINEAR EXPANSION -- HAFNIUM DIOXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	57-35	293-1623		97.9 HfO_2 and 2.1 MgO.	Corresponding to 90 mole % HfO_2 and 10 mole % MgO; author reported mean expansion coeff. over range.
△	57-35	293-1623		95.4 HfO_2 and 4.6 MgO.	Corresponding to 80 mole % HfO_2 and 20 mole % MgO; same as above.

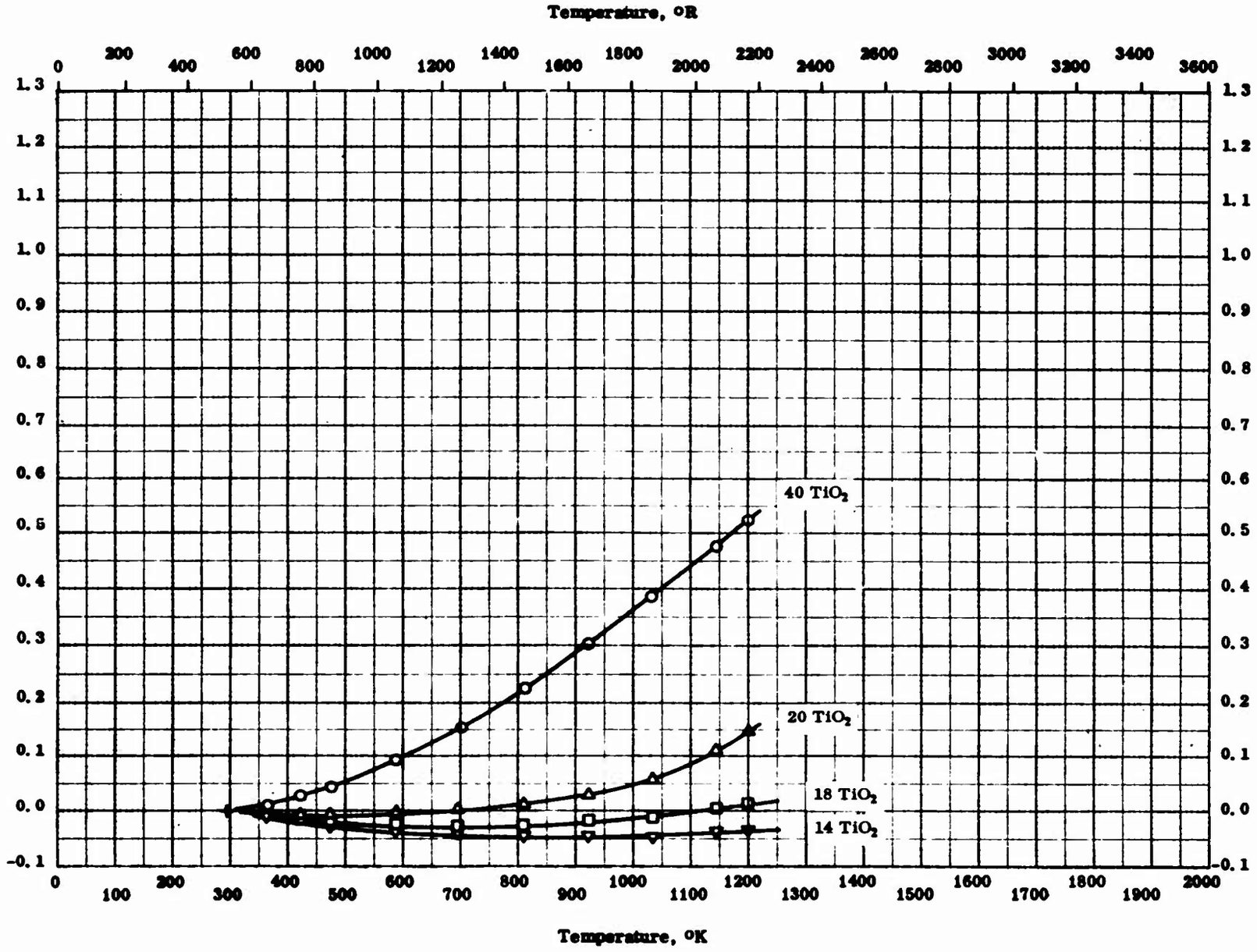


THERMAL LINEAR EXPANSION -- HAFNIUM DIOXIDE + TANTALUM PENTOXIDE

THERMAL LINEAR EXPANSION -- HAFNIUM DIOXIDE + TANTALUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-35	293-1623		$6HfO_2 \cdot Ta_2O_5$; Ta_2O_5 impurities: 1 Ta and Si and 0.05 - 0.1 F and Ti; HfO_2 impurities: 1 Th, 0.05 - 1 V, 0.0 - 0.5 Na, and 0.01 - 0.05 Al and Ti.	

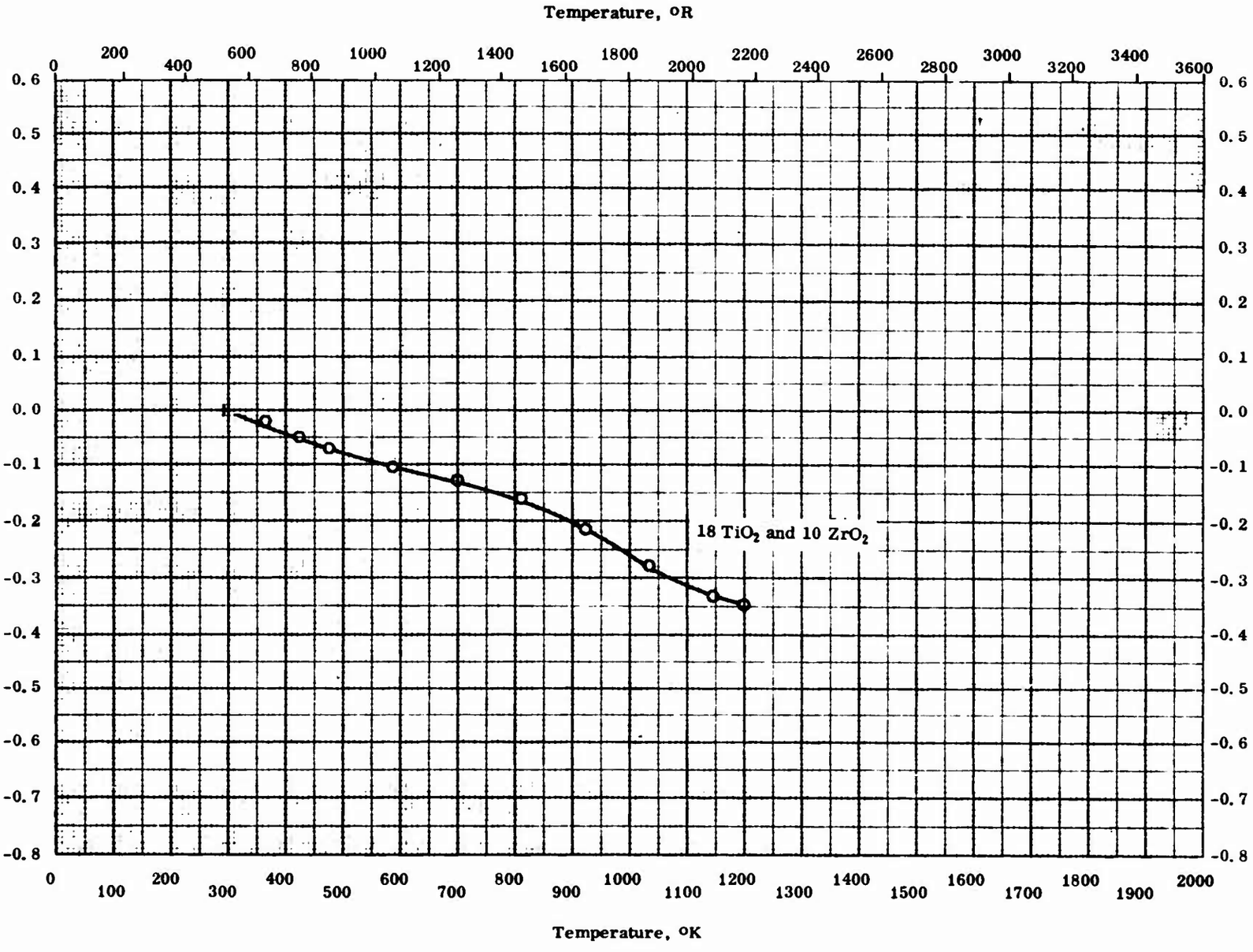


THERMAL LINEAR EXPANSION -- HAFNIUM DIOXIDE + TITANIUM DIOXIDE

THERMAL LINEAR EXPANSION -- HAFNIUM DIOXIDE + TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	60-40	293-1200		60 HfO_2 and 40 TiO_2 from Boeing Airplane Co.	Reference temperature not given, assumed to be 68 F.
△	60-40	293-1200		80 HfO_2 and 20 TiO_2 from Boeing Airplane Co.	Same as above.
□	60-40	293-1200		82 HfO_2 and 18 TiO_2 from Boeing Airplane Co.	Same as above.
▽	60-40	293-1200		86 HfO_2 and 14 TiO_2 from Boeing Airplane Co.	Same as above.

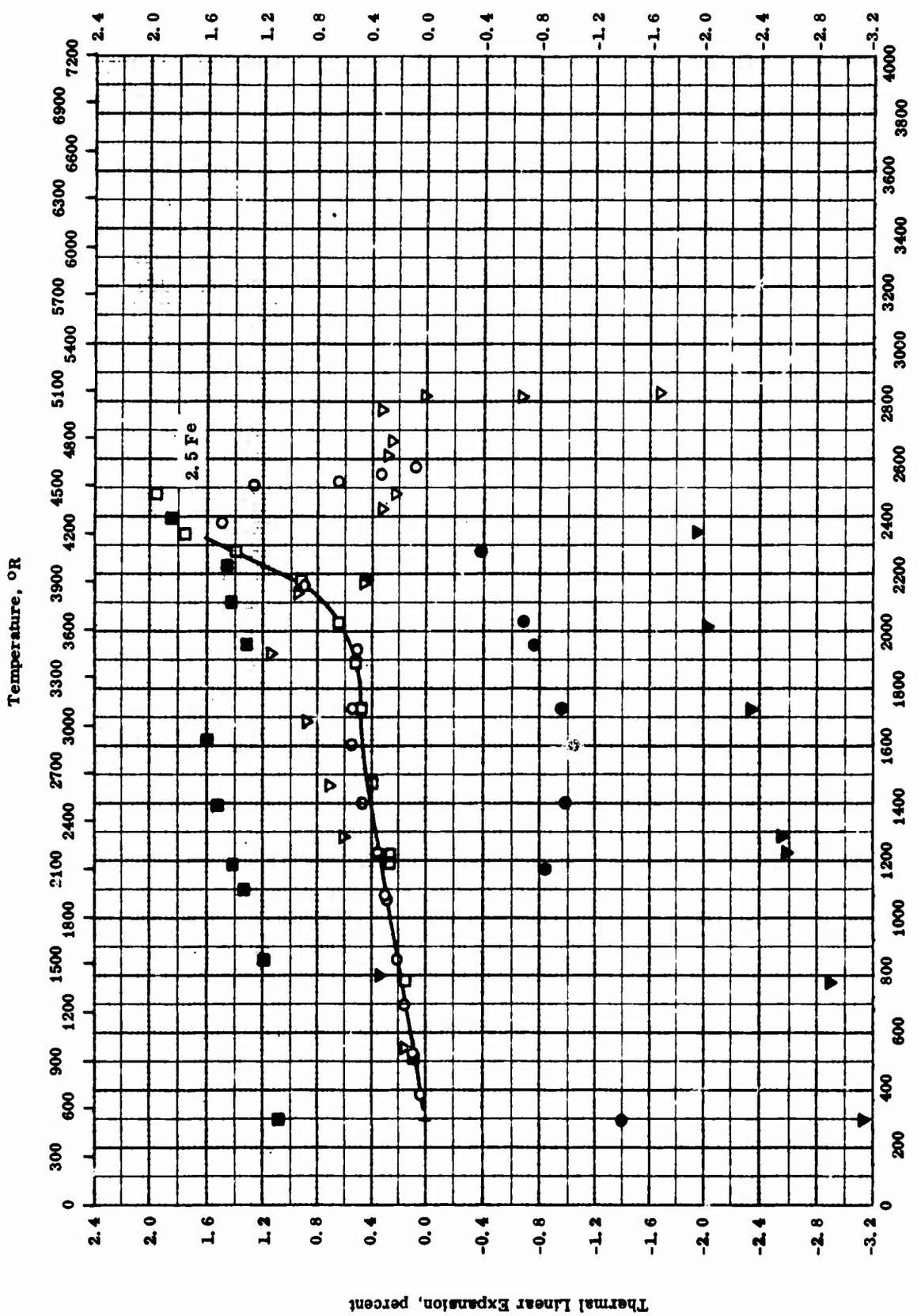


THERMAL LINEAR EXPANSION -- HAFNIUM DIOXIDE + TITANIUM DIOXIDE + ZIRCONIUM DIOXIDE

THERMAL LINEAR EXPANSION -- HAFNIUM DIOXIDE + TITANIUM DIOXIDE + ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	60-40	293-1200		72 HfO_2, 18 TiO_2, and 10 ZrO_2.	Reference temperature not given, assumed to be 68 F.

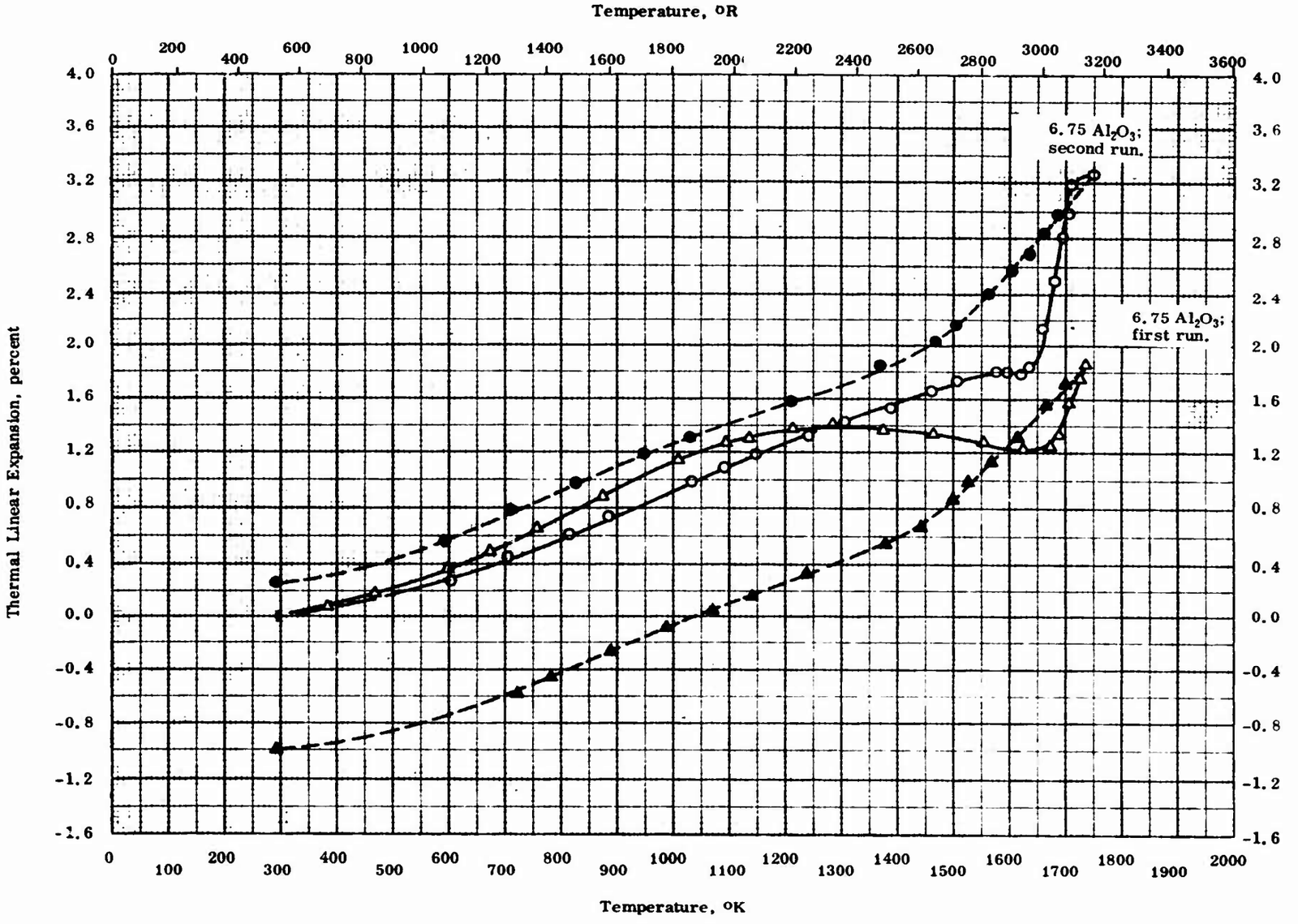


THERMAL LINEAR EXPANSION -- HAFNIUM DIOXIDE + ΣX_i

THERMAL LINEAR EXPANSION -- HAFNIUM DIOXIDE + ΣX_i

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-4	294-2572	5	Supplied by Zirconium Corp. of America; 82.0 Hf; elements found by semi-quantitative emission spectrography before exposure 2.5 Fe, 0.3 Mg, 0.1 Ti, and 0.1 Ca; after exposure 84.0 Hf and 0.51 C; density in $g\,cm^{-3}$ at 25 C by ASTM method B311-58 before exposure 9.00, after exposure 8.93; initial length 2.240 in., final length 2.238 in. [Author's design : Run No. E15]	Pressed and sintered; measured in helium atm.
●	62-4	294-2572	5	Same as above.	Cooling cycle for above sample.
▽	62-4	294-2825	5	Same as above; inital length 2.238 in., final length 2.234 in. [Author's design : Run No. E 16]	Second heating cycle for above sample (Run No. E 15); sample deteriorated.
▼	62-4	294-2825	5	Same as above.	Second cooling cycle for above sample.
□	62-4	294-2481	5	Same as above; initial length 2.837 in., final length 2.875 in. [Author's design : Run No. E 18]	Pressed and sintered; measured in helium atm.
■	62-4	294-2481	5	Same as above.	Cooling cycle for above sample.



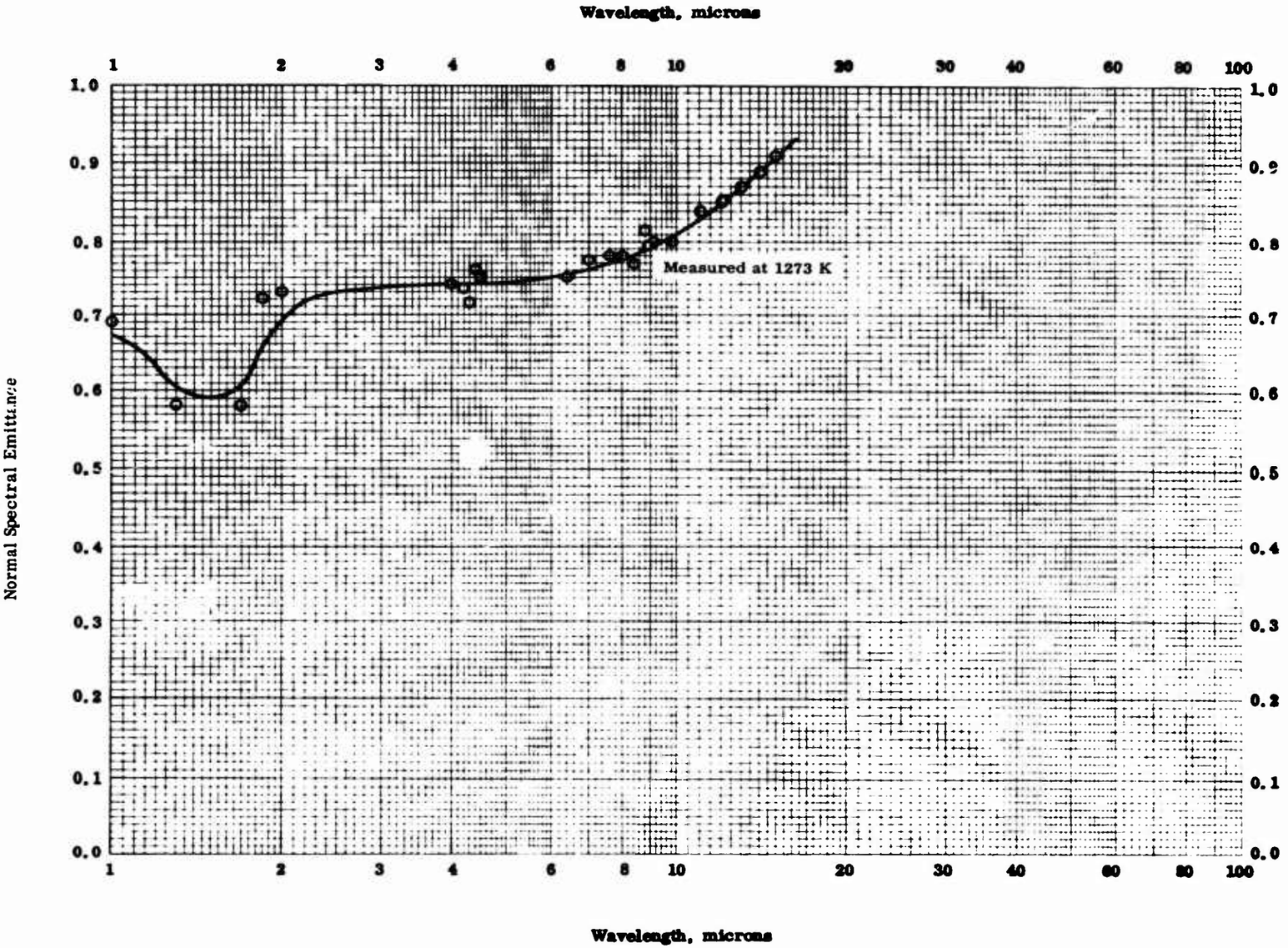
THERMAL LINEAR EXPANSION -- IRON(IC) OXIDE + ALUMINUM OXIDE

THERMAL LINEAR EXPANSION -- IRON(IC) OXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
△	64-22	293-1733		93.25 Fe_2O_3 and 6.75 Al_2O_3; dimension 2 cm diameter by 7 cm long.	Ferric oxide prepared by calcining pure ferrous oxalate at 1000 C; alumina prepared from commercially pure powder calcined at 1000 C; sample prepared from finely-divided Fe_2O_3 and Al_2O_3 mixtures bonded with dextrin and water, compacted into cylinders, and fired; measured in air atm with heating rage of 10 C min^{-1}.
▲	64-22	293-1733		Same as above.	Cooling cycle for above sample.
○	64-22	293-1749		Same as above.	Second heating cycle for above sample.
●	64-22	293-1749		Same as above.	Second cooling cycle for above sample.

TPRC

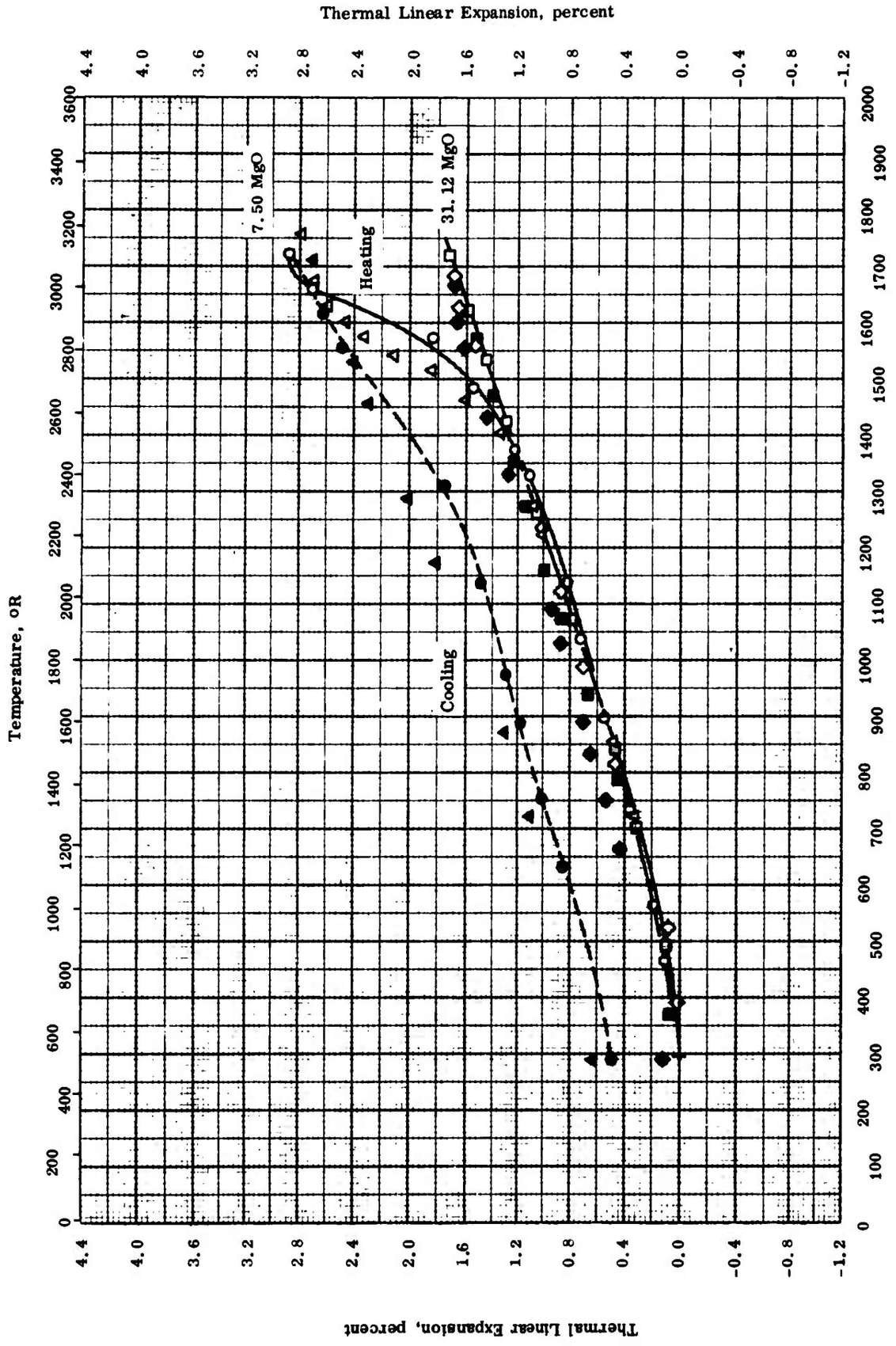


NORMAL SPECTRAL EMITTANCE -- FERROFERRIC OXIDE + IRON (IC) OXIDE

NORMAL SPECTRAL EMITTANCE — FERROFERRIC OXIDE + IRON (IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
O	62-23	1273	1-15		75 Fe_3O_4 and 25 Fe_2O_3; dominantly noncrystalline; 0.047 in. thickness plate.	Sintered at 1673 K for 2 hrs; measured in air; data taken from a curve.

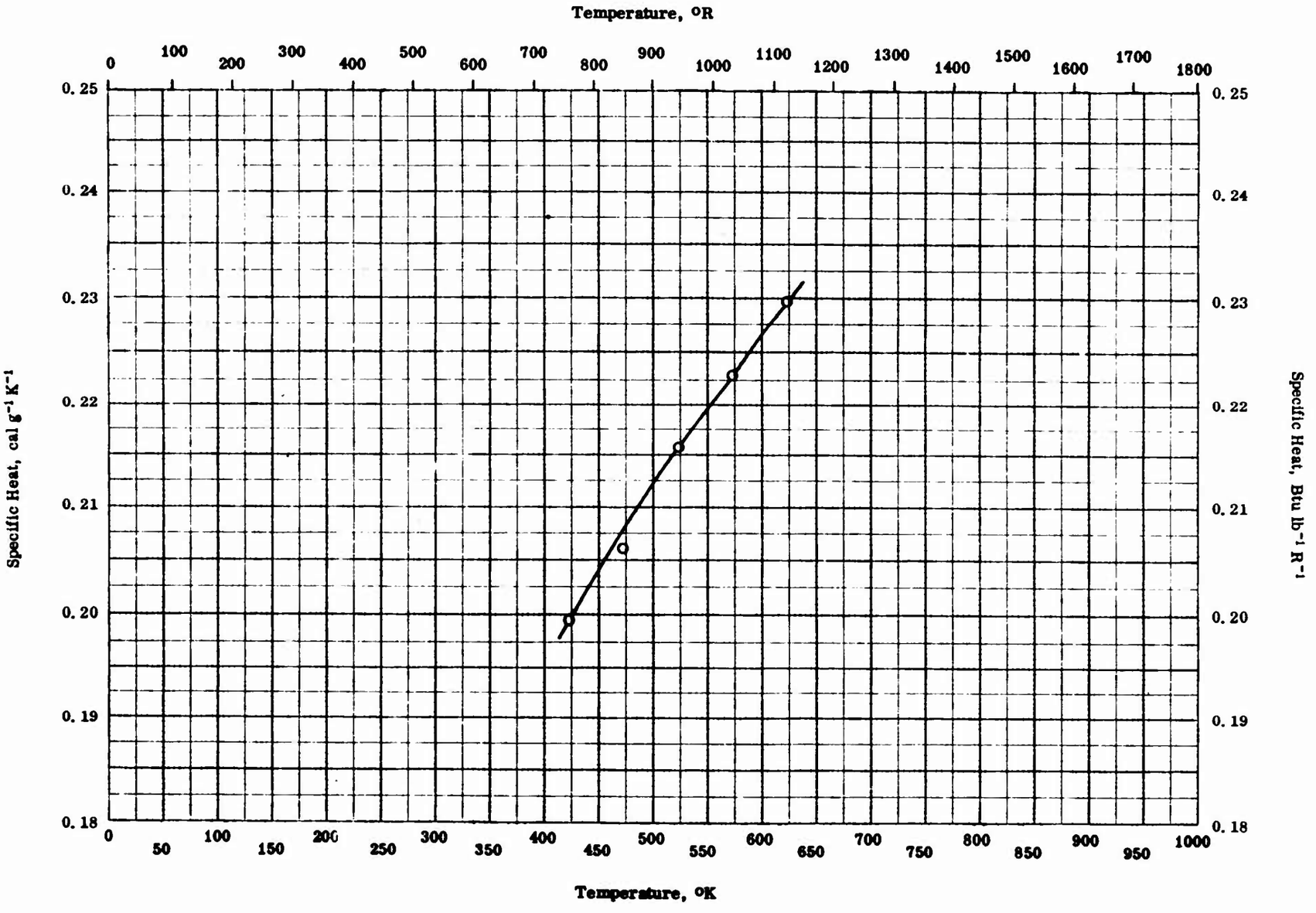


THERMAL LINEAR EXPANSION -- IRON(IC) OXIDE + MAGNESIUM OXIDE

THERMAL LINEAR EXPANSION -- IRON(IC) OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	64-22	293-1721		92.50 Fe_2O_3 and 7.50 MgO; dimensions 2 cm diameter by 7 cm long.	Ferric oxide prepared by calcining pure ferrous oxalate at 1000 C; magnesia prepared by calcining pure magnesium carbonate (B. P. grade) to 1600 C and grinding to pass a 100-mesh B.S. sieve; sample prepared from finely-divided Fe_2O_3 and MgO mixtures bonded with dextrin and water, compacted into cylinders, and fired; measured in air atm with heating rate of 10 C min^{-1}.
●	64-22	293-1721		Same as above.	Cooling cycle for above sample.
△	64-22	298-1753		Same as above.	Same as heating cycle for above sample except measured in nitrogen atm.
▲	64-22	293-1753		Same as above.	Cooling cycle for above sample.
□	64-22	293-1717		68.88 Fe_2O_3 and 31.12 MgO; dimensions 2 cm diameter by 7 cm long.	Same as heating cycle for above sample except measured in air atm.
■	64-22	369-1717		Same as above.	Cooling cycle for above sample.
◇	64-22	293-1715		Same as above.	Same as heating cycle for above sample.
◆	64-22	293-1715		Same as above.	Cooling cycle for above sample.



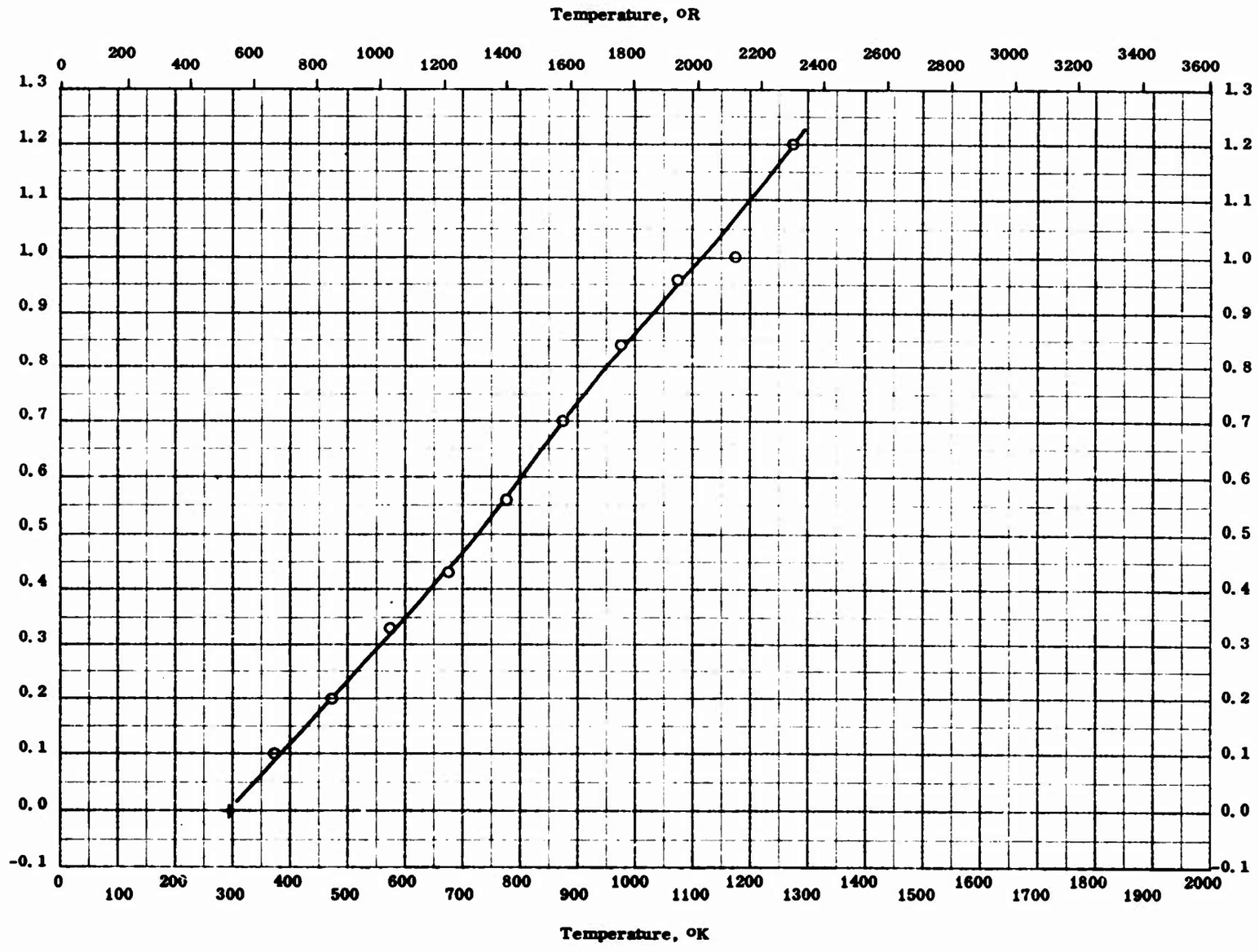
SPECIFIC HEAT -- IRON (IC) OXIDE + SILICON DIOXIDE

SPECIFIC HEAT -- IRON (IC) OXIDE + SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	61-11	423-623		Limonite Bhadravati Musore; 85.05 Fe_2O_3, 4.780 SiO_2, 4.702 H_2O, 3.75 Al_2O_3, and 1.715 FeO.	

TPRC

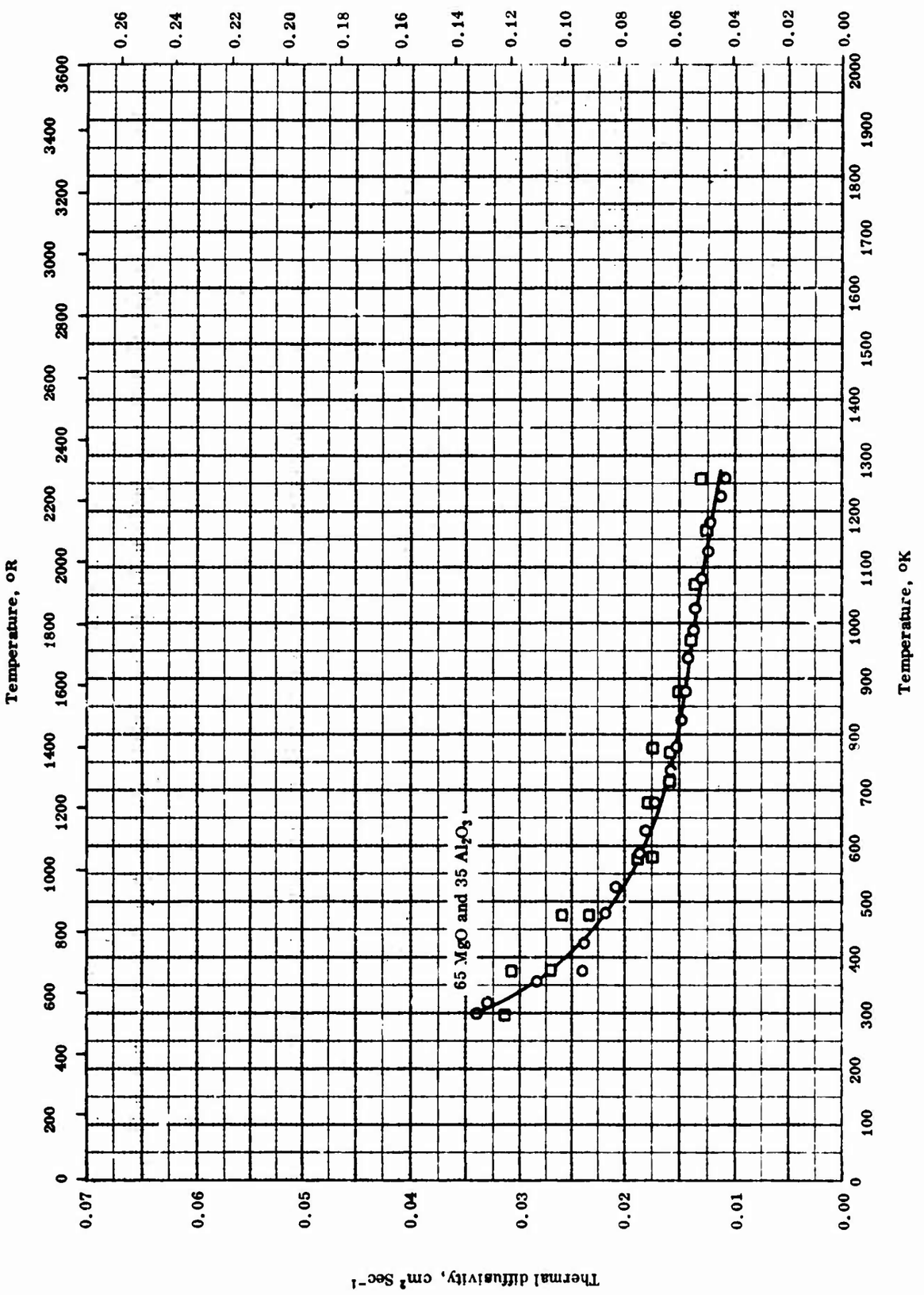


THERMAL LINEAR EXPANSION -- IRON (OUS) OXIDE + ΣX_j

THERMAL LINEAR EXPANSION -- IRON(OUS) OXIDE + ΣX_i

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	46-5	373-1273		90 FeO; density 346 lb ft^{-3}.	

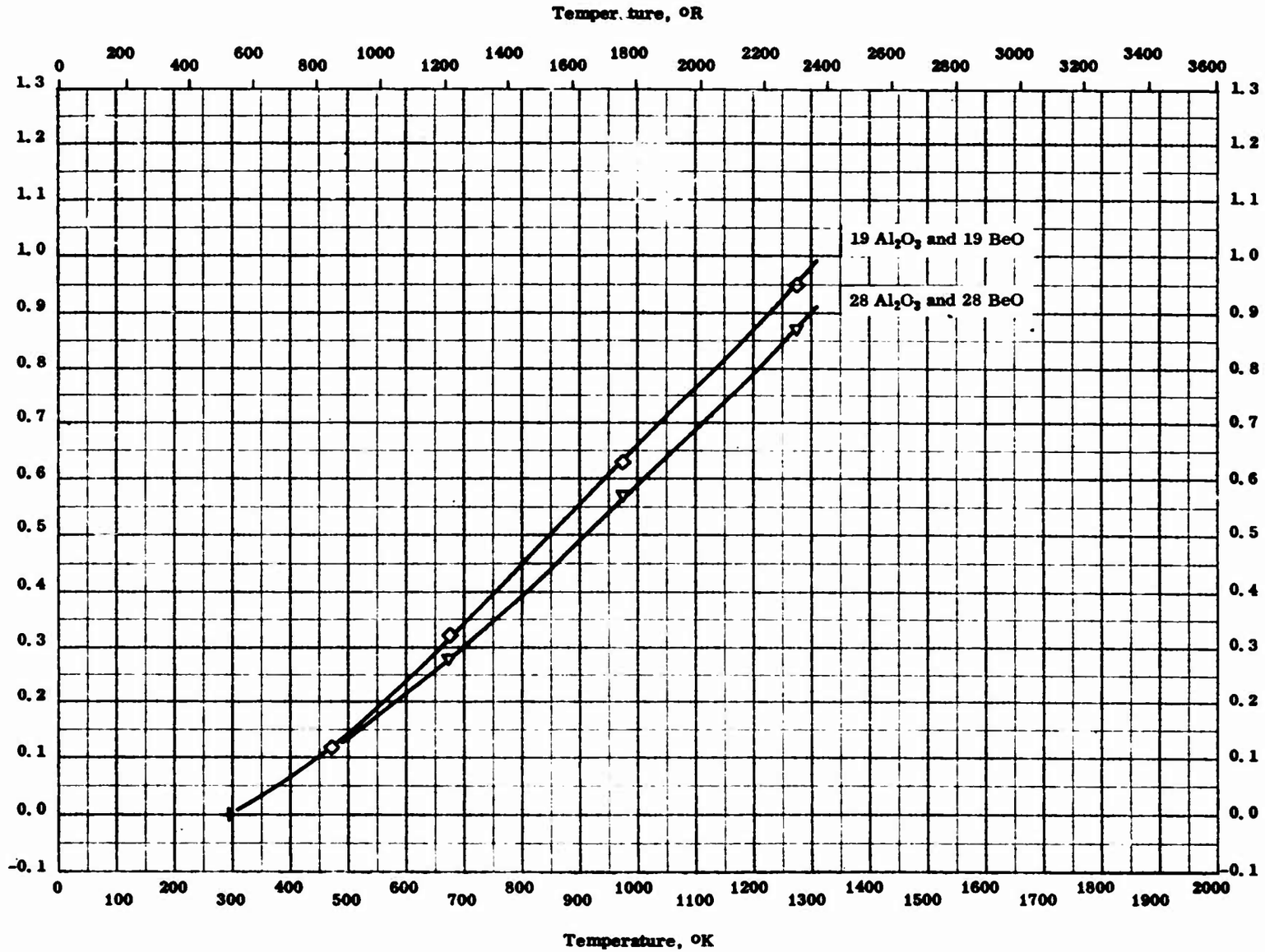


THERMAL DIFFUSIVITY -- MAGNESIUM OXIDE + ALUMINUM OXIDE

THERMAL DIFFUSIVITY -- MAGNESIUM OXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-1	293-1258	15	65.0 MgO and 35.0 Al_2O_3.	
□	62-1	298-1258	15	Same as above.	Measured by using comparative method

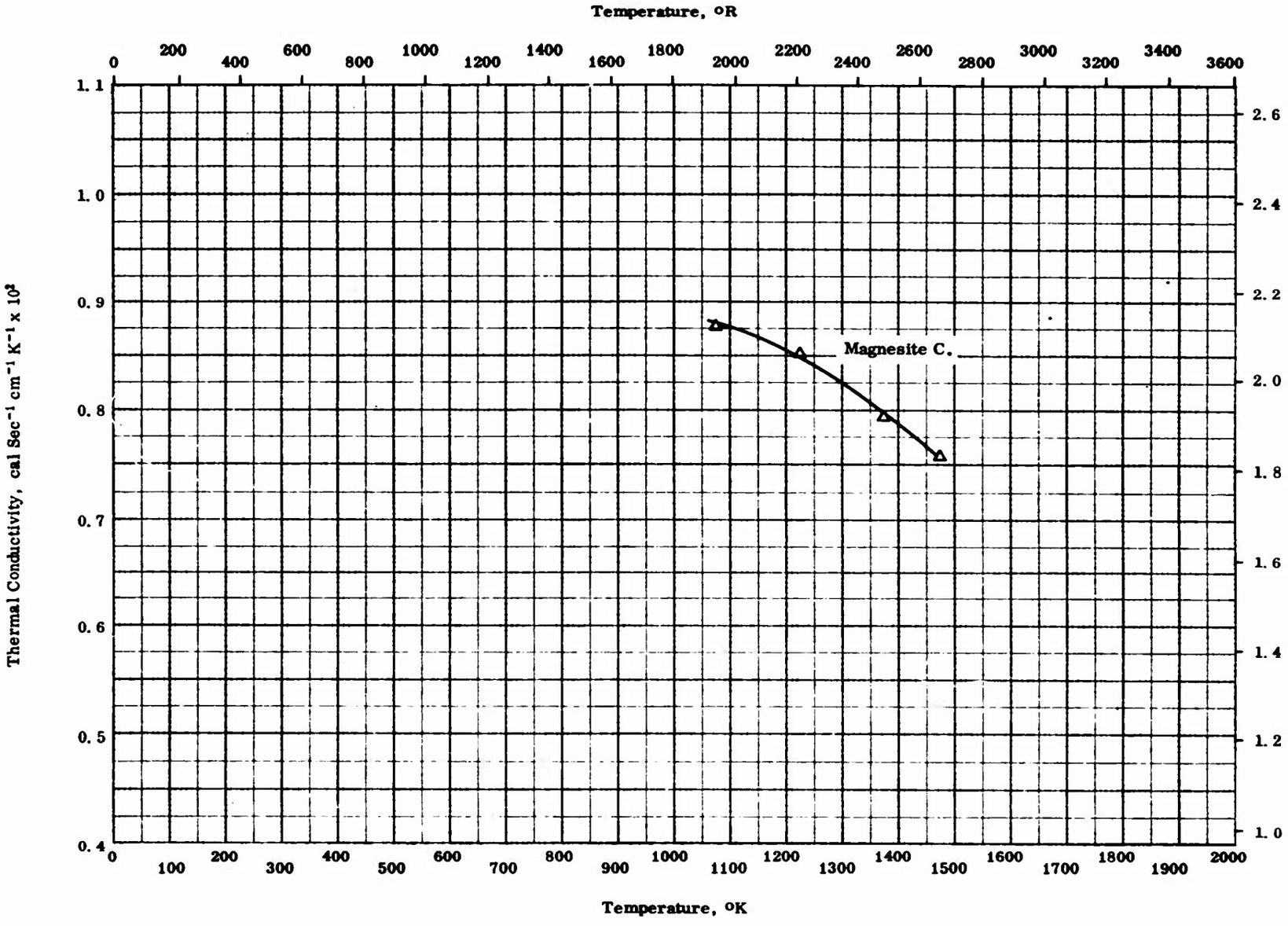


THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE + ALUMINUM OXIDE + BERYLLIUM OXIDE

THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE + ALUMINUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◇	46-4	293-1273		61.49 MgO, 19.44 Al_2O_3, and 19.07 BeO ($8MgO \cdot 4BeO \cdot Al_2O_3$); prepared from 97 pure MgO, 99.7 pure BeO and 99+ pure Al_2O_3.	
▽	46-4	293-1273		44.40 MgO, 28.06 Al_2O_3, and 27.54 BeO ($4MgO \cdot 4BeO \cdot Al_2O_3$); raw materials same as above.	

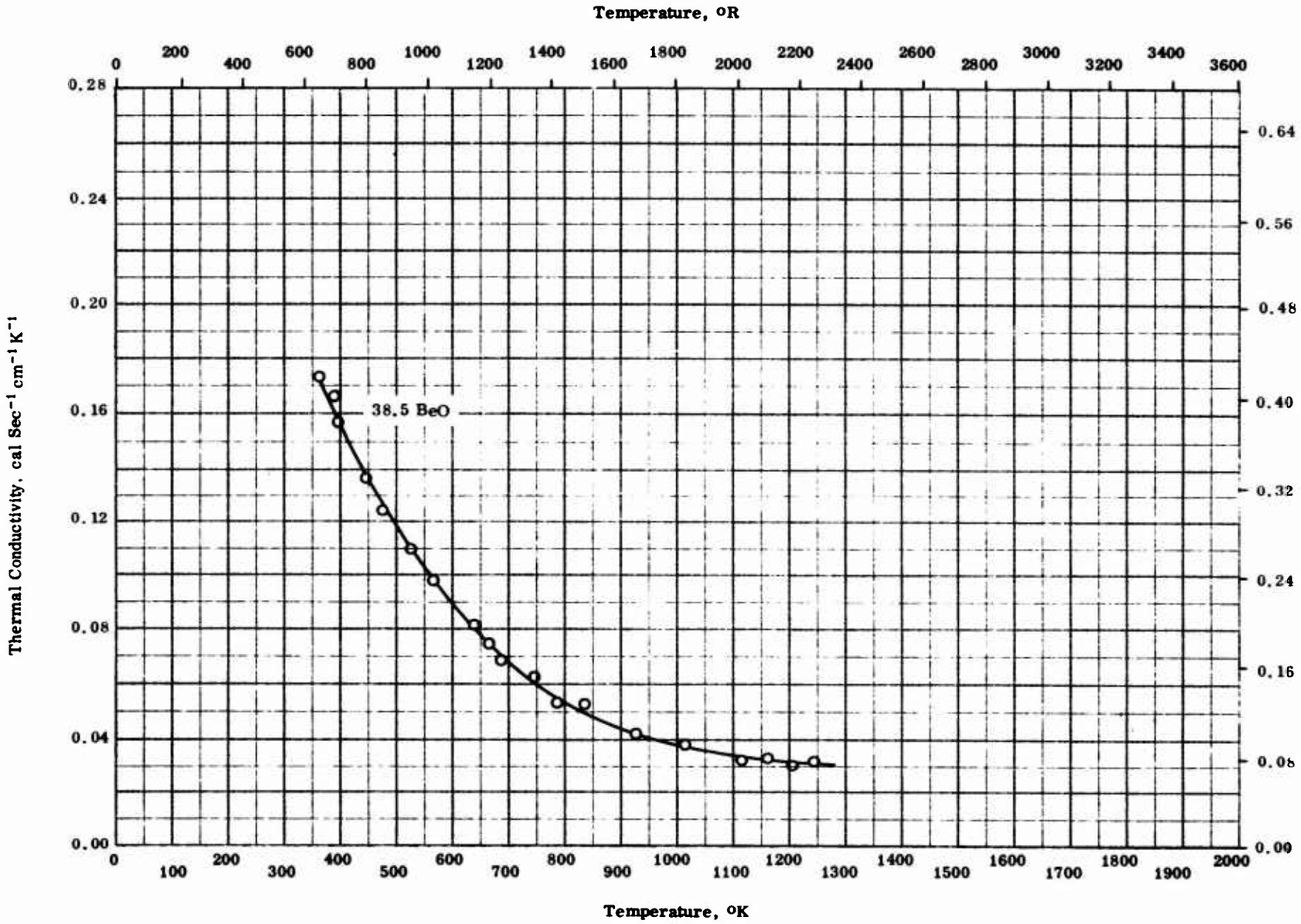


THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + ALUMINUM OXIDE +
+ IRON(IC) OXIDE + SILICON DIOXIDE + CALCIUM OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + ALUMINUM OXIDE + + IRON(IC) OXIDE + SILICON DIOXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
Δ	57-2	1073-1473	± 5	Magnesite C; 85.86 MgO, 4.99 Al_2O_3, 3.73 Fe_2O_3, 3.28 SiO_2, 2.06 CaO, 0.13 Na_2O, 0.06 K_2O, and 0.16 loss on ignition; density 182 lb ft^{-3}; apparent porosity 17.8%.	Calcined.

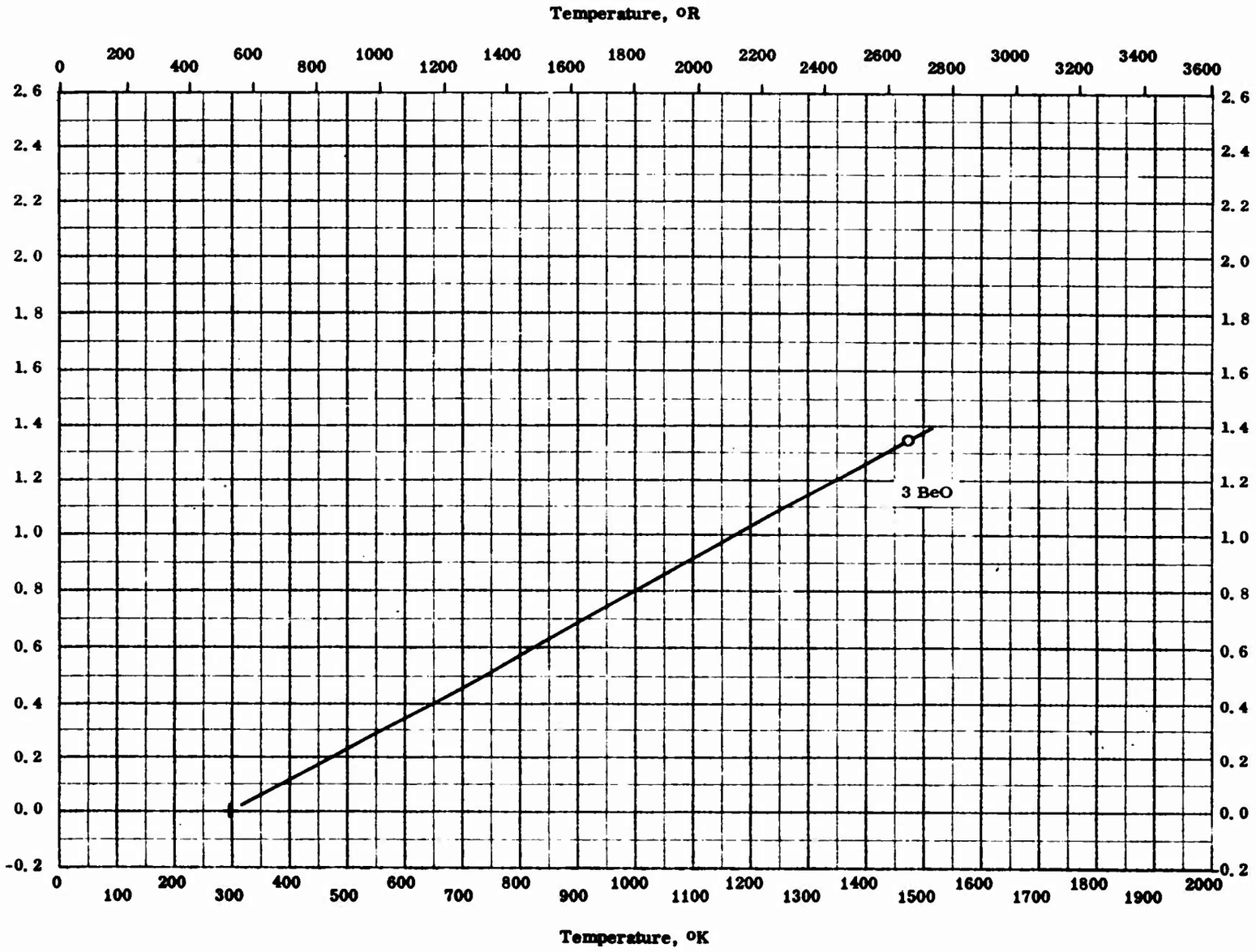


THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + BERYLLIUM OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	59-1	361-1243		61.5 MgO and 38.5 BeO; fired bulk density 2.43 g cm^{-3} and total porosity 25.7%.	Corresponding to 54.3 vol. % BeO; sintered at 1800 C.



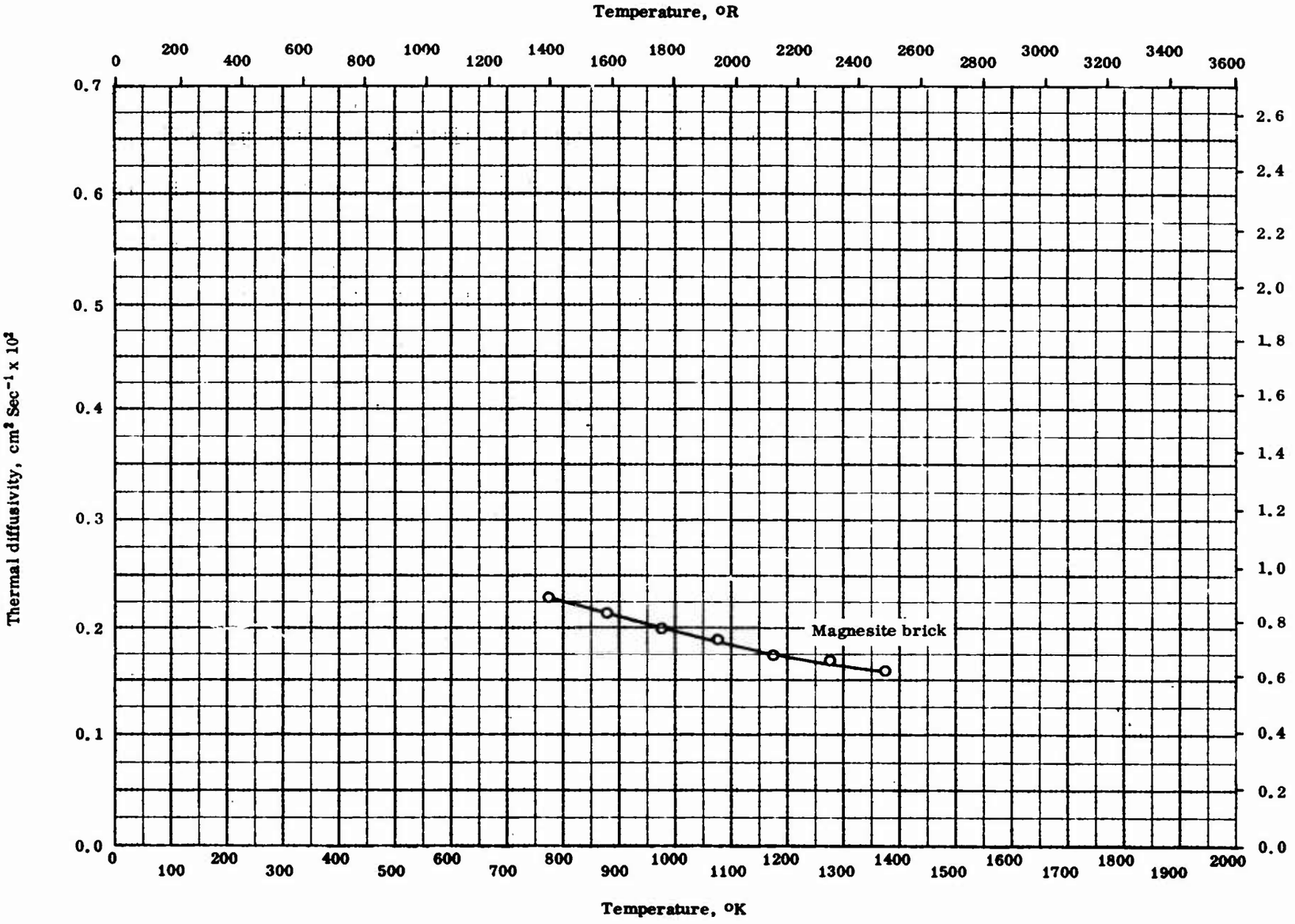
THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE + BERYLLIUM OXIDE

THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	46-7	293-1473		97 MgO and 3 BeO; density 156 lb ft^{-3} and porosity 29% for 2.5 BeO sample fired at 1450 C.	Heated at 4 C min^{-1}.

TPRC

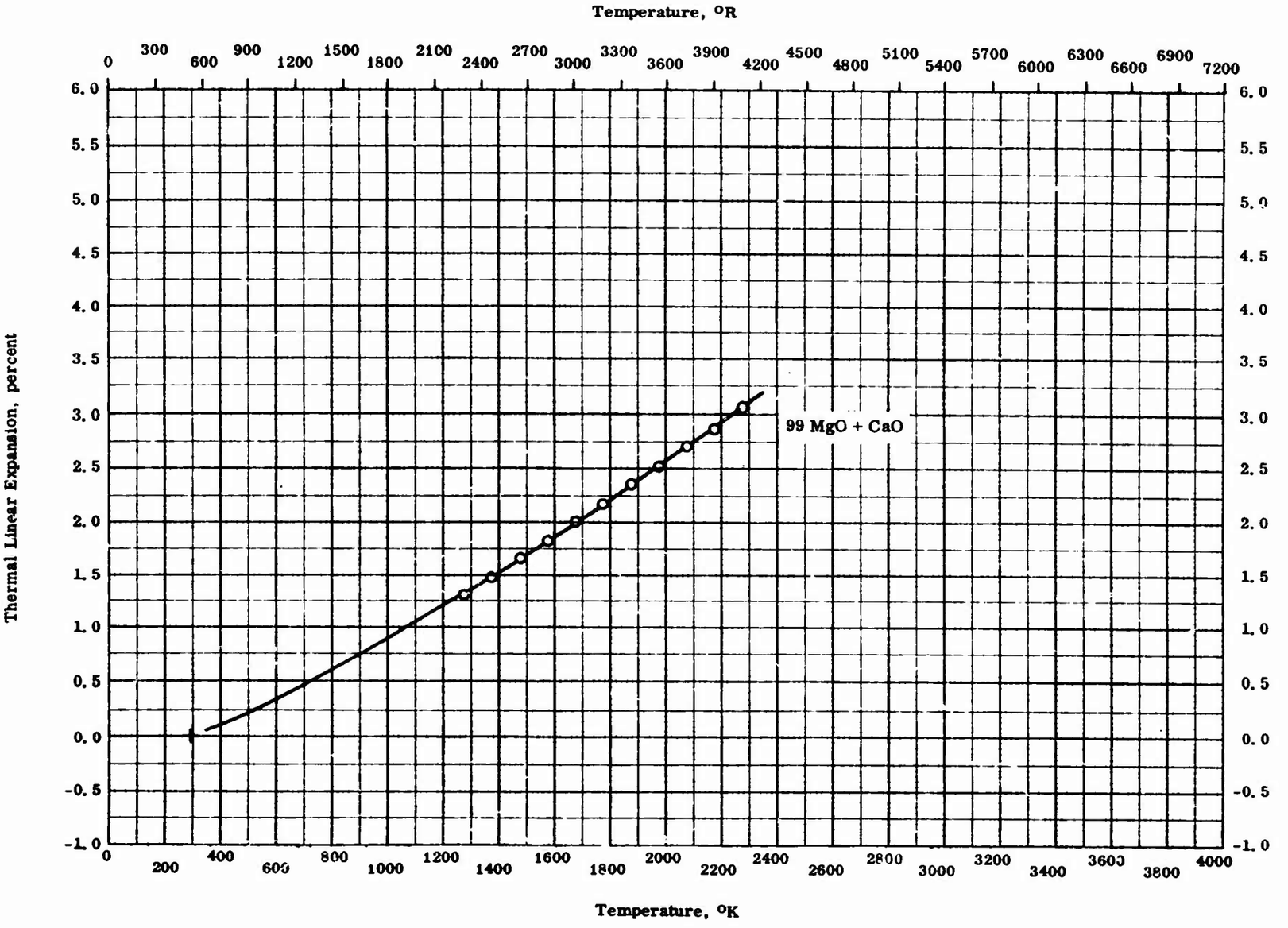


THERMAL DIFFUSIVITY -- MAGNESIUM OXIDE + CALCIUM OXIDE

THERMAL DIFFUSIVITY -- MAGNESIUM OXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	21-1	773-1373		Magnesite brick; 81.79 MgO, 5.24 CaO, and 1.87 Fe_2O_3; texture very close; 20.0% porosity and 3.29 true specific gravity; specimen dimension 9 by 4 1/2 by 2 1/2 in.	Heat flow in lengthwise direction.

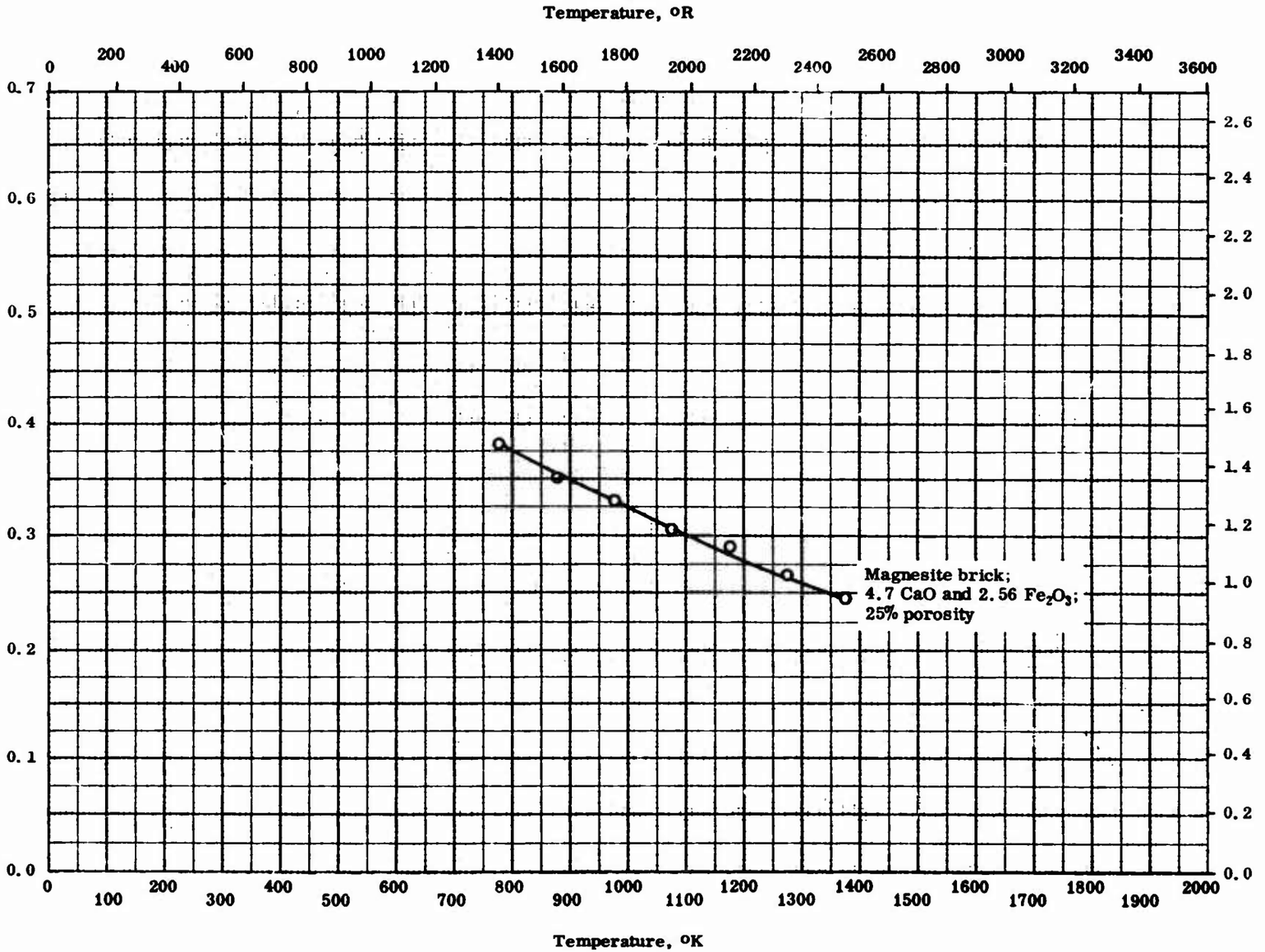


THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE + CALCIUM OXIDE

THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-36	293-2273		99.0 MgO + CaO; dimension 4 by 4 by 20 mm; bulk density 3.40 g cm^{-3}; apparent porosity 0.0%. [Author's design : Body 14]	Prepared from commercial magnesia pressed at 1000 Kg cm^{-2} and fired at 1950 C; rate of temperature rise 5 - 8 C min^{-1}; measured in vacuum furnace; authors reported average coefficients.

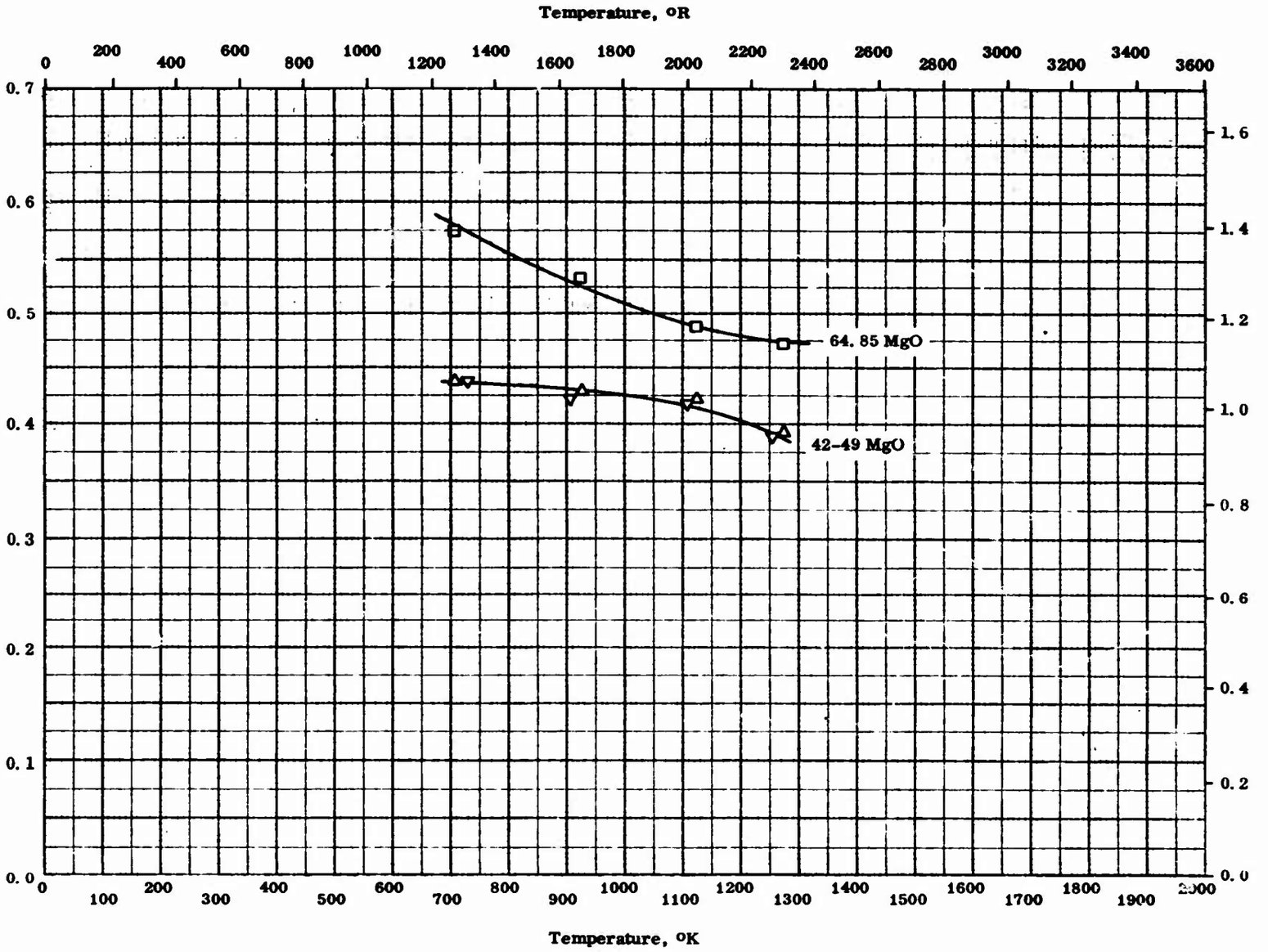


THERMAL DIFFUSIVITY -- MAGNESIUM OXIDE + CALCIUM OXIDE + IRON(IC) OXIDE

THERMAL DIFFUSIVITY -- MAGNESIUM OXIDE + CALCIUM OXIDE + IRON(IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	21-1	773-1373		Magnesite brick; 87.88 MgO, 4.68 CaO, and 2.56 Fe_2O_3; close texture; 24.5% porosity and 3.38 true specific gravity; sample dimension 9 by 4 1/2 by 2 1/2 in.	Heat flow in lengthwise direction



Thermal Conductivity, cal Sec^{-1} cm^{-1} K^{-1} x 10^4

Thermal Conductivity, Btu hr^{-1} ft^{-1} R^{-1}

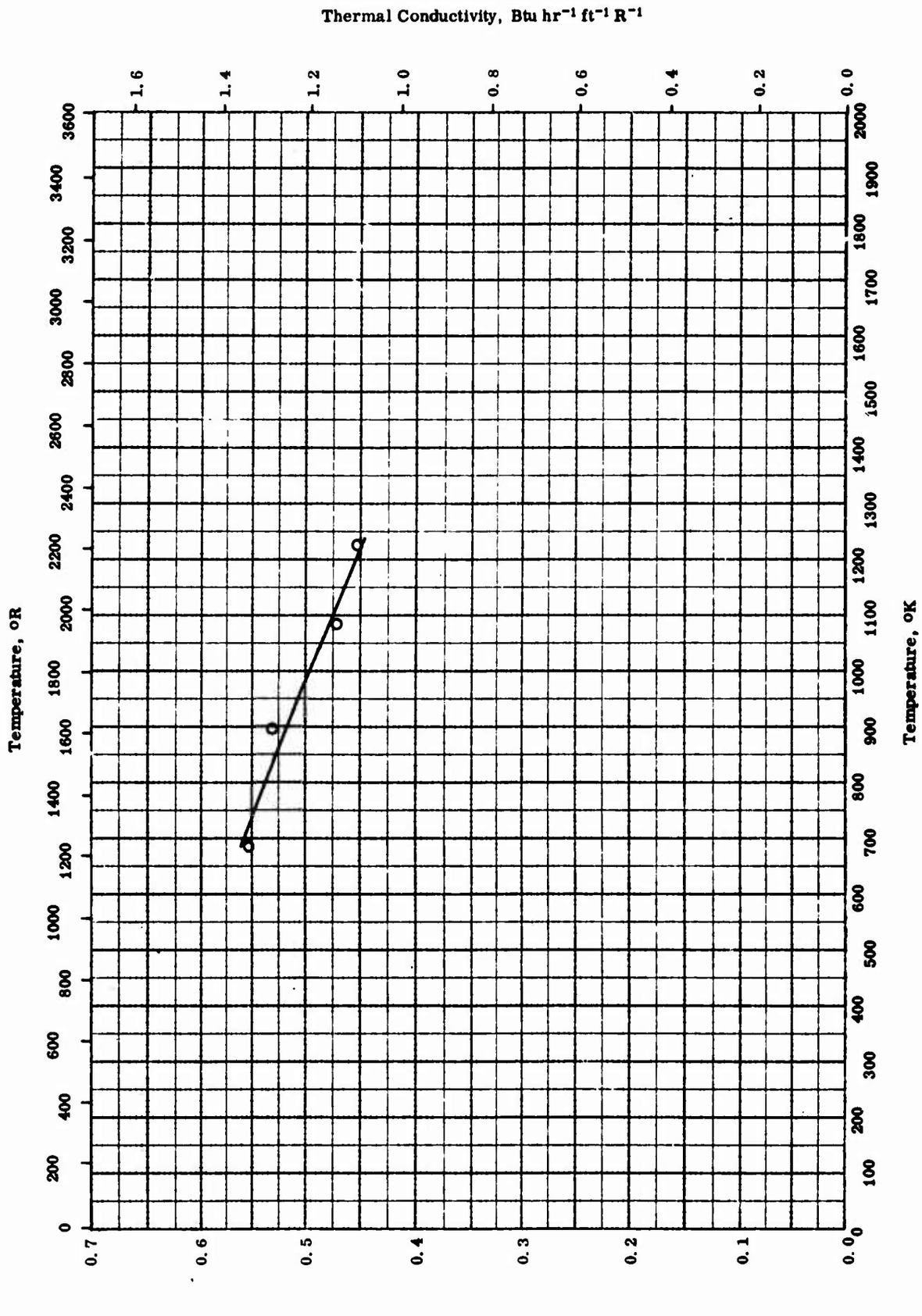
TPRC

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + CHROMIUM SESQUIOXIDE +
+ ALUMINUM OXIDE + IRON(IC) OXIDE + SILICON DIOXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + CHROMIUM SESQUIOXIDE + + ALUMINUM OXIDE + IRON(IC) OXIDE + SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	55-4	723-1273		Magnezit; 64.85 MgO, 12.28 Cr_2O_3, 8.57 Al_2O_3, 5.80 Fe_2O_3, 4.28 SiO_2, 1.67 FeO, and 1.44 CaO; porosity 19.1% and density 190 lb ft^{-3}.	
△	55-4	723-1273		Magnezit; 49.46 MgO, 20.48 Cr_2O_3, 12.59 Al_2O_3, 9.15 Fe_2O_3, 5.24 SiO_2, 1.90 FeO, and 1.26 CaO; porosity 22.8% and density 184 lb ft^{-3}.	
▽	55-4	723-1273		Marksa; 42.31 MgO, 24.35 Cr_2O_3, 12.34 Al_2O_3, 11.94 Fe_2O_3, 6.14 SiO_2, 1.71 FeO and 1.65 CaO; porosity 23.5% and density 189 lb ft^{-3}.	



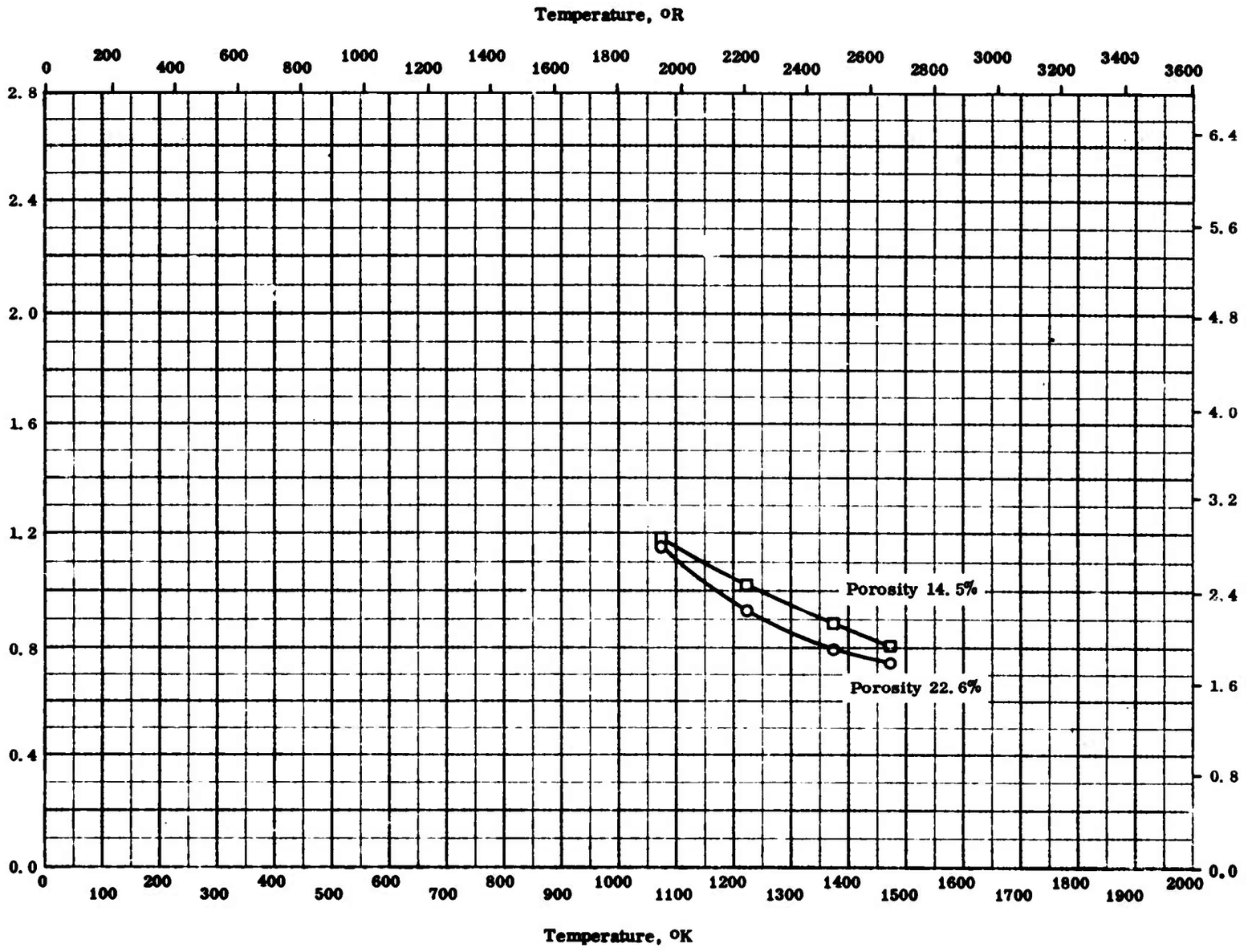
THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + CHROMIUM SESQUIOXIDE + IRON(IC) OXIDE + + ALUMINUM OXIDE + SILICON DIOXIDE + IRON(OUS) OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + CHROMIUM SESQUIOXIDE + IRON(IC) OXIDE + + ALUMINUM OXIDE + SILICON DIOXIDE + IRON(OUS) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	55-4	683-1228		Ordzhonikidze chromomagnesite refractory brick; 42.87 MgO, 22.34 Cr_2O_3, 13.04 Fe_2O_3, 11.46 Al_2O_3, 5.42 SiO_2, 2.88 FeO, 1.76 CaO, and trace of Ca, Mg, Fe, and Mn; density 2.95 g cm^{-3}, apparent porosity 25.6%, and gas permeability 5.98 ml m^{-2} hr^{-1} (mm of water column)$^{-1}$.	

TPRC



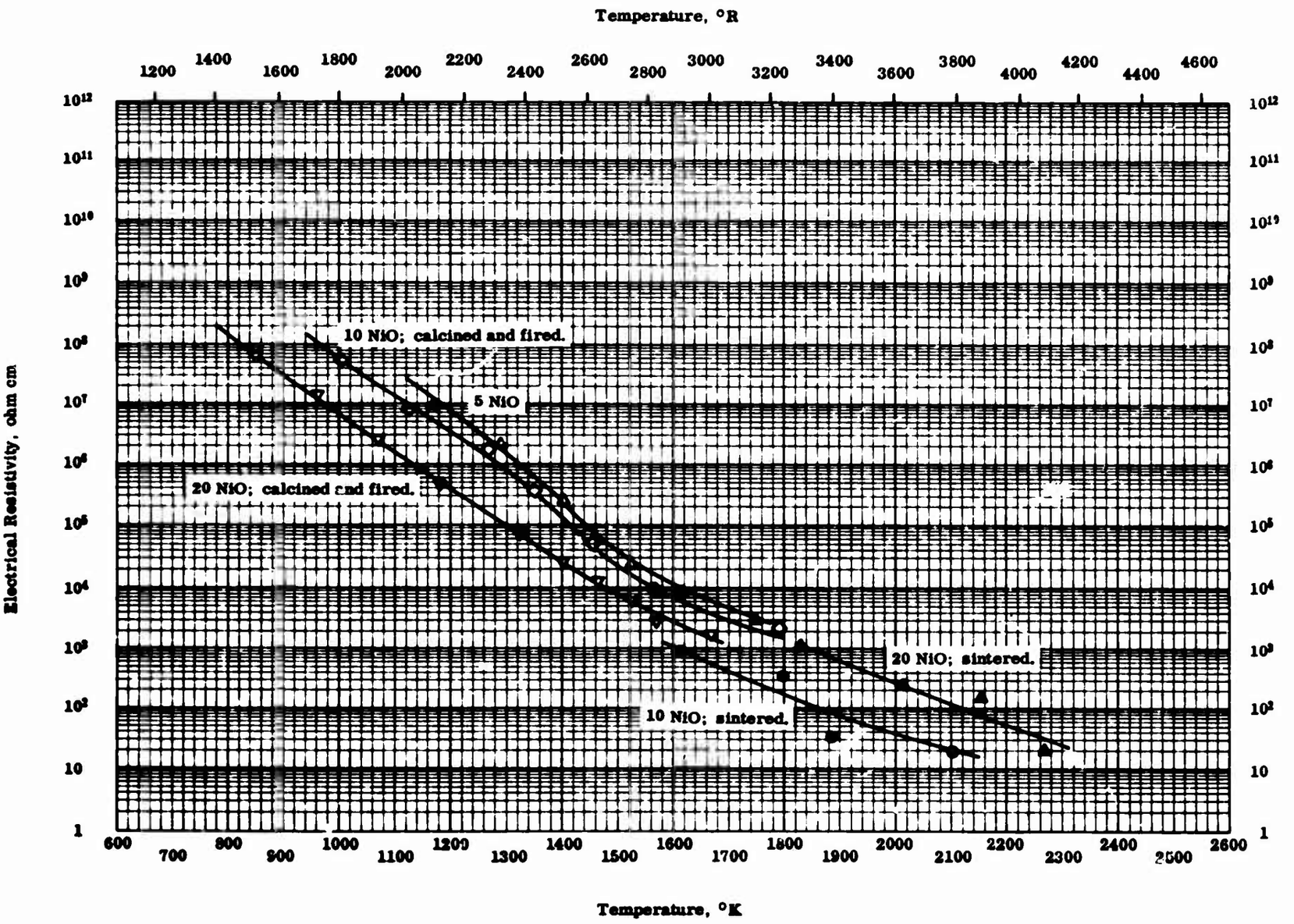
THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + IRON(IC) OXIDE + CALCIUM OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + IRON(IC) OXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	57-2	1073-1473	± 5	Magnesite B; 93.10 MgO, 2.78 Fe_2O_3, 2.16 CaO; 1.22 SiO_2, 0.54 Al_2O_3, 0.12 TiO_2, 0.03 Na_2O, 0.01 K_2O, and 0.12 loss on ignition; density 172 lb ft^{-3}; apparent porosity 22.6%.	Calcined.
□	57-2	1073-1473	± 5	Magnesite A; 90.08 MgO, 3.91 Fe_2O_3, 3.40 CaO, 1.68 SiO_2, 0.75 Al_2O_3, 0.14 TiO_2, 0.04 Na_2O, 0.01 K_2O, and 0.10 loss on ignition; density 192 lb ft^{-3}; apparent porosity 14.5%.	Calcined.

TPRC

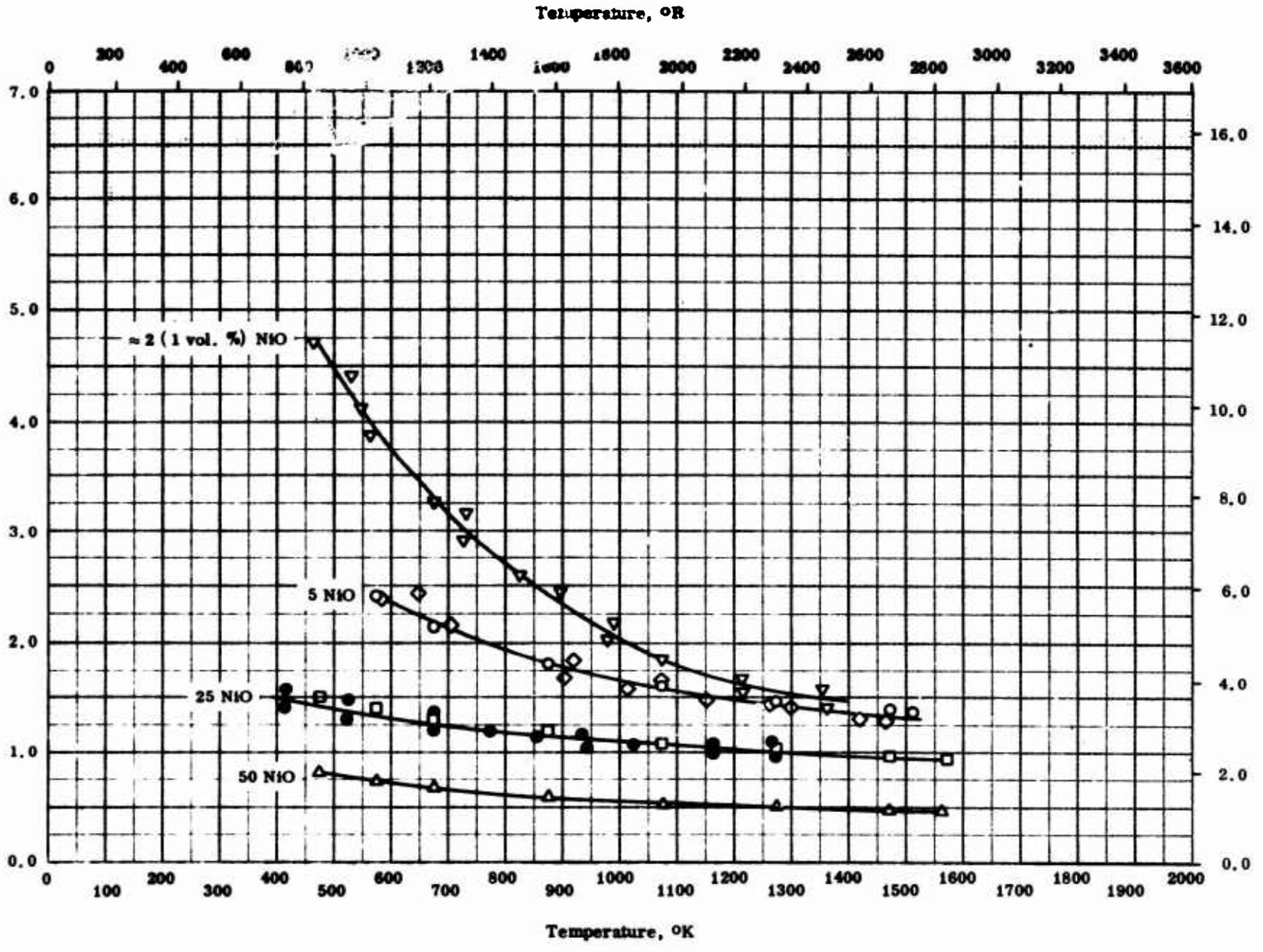


ELECTRICAL RESISTIVITY -- MAGNESIUM OXIDE + NICKEL MONOXIDE

ELECTRICAL RESISTIVITY -- MAGNESIUM OXIDE + NICKEL MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Max. Error %	Sample Specifications	Remarks
△	53-17	1173-1753		95 MgO and 5 NiO; prepared from c.p. MgO and NiO.	Wet-mixed in Mullite mortar and dried; calcined to 1000 C in Pt and fired 10 hrs at 1500 C.
◇	53-17	1003-1773		90 MgO and 10 NiO, same as above.	Same as above.
▽	53-17	853-1673		80 MgO and 20 NiO; same as above.	Same as above.
●	60-19	1643-2100		90 MgO and 10 NiO	Sintered at 1200 C for 10 hrs.
▲	60-19	1923-2273		80 MgO and 20 NiO.	Same as above.

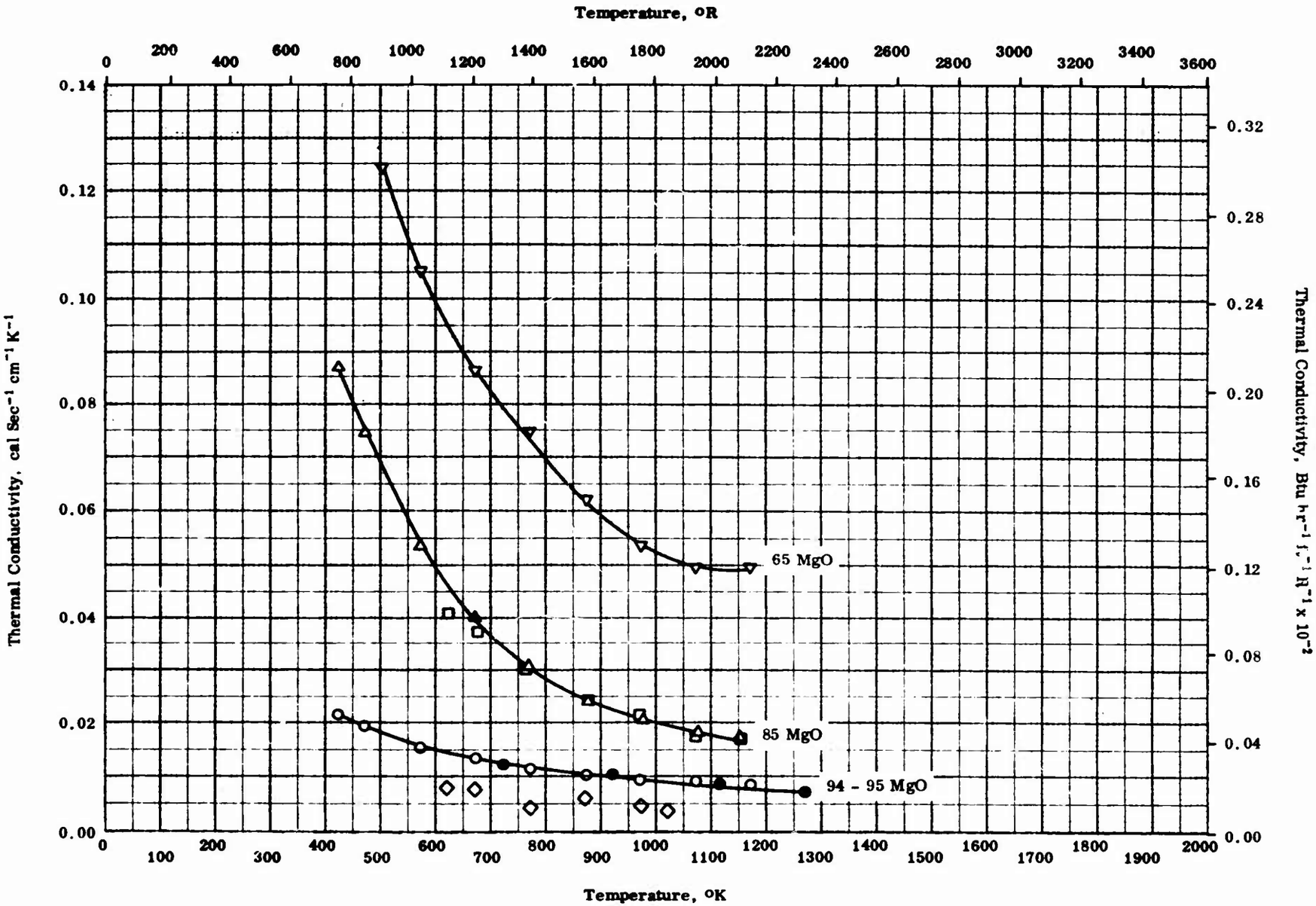


THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + NICKEL MONOXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + NICKEL MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-2	573-1513		5 NiO.	Data corrected to zero porosity.
□	54-2	473-1573		25 NiO.	Same as above.
△	54-2	473-1563		50 NiO.	Same as above.
▽	59-1	464-1361	± 4	99.5 MgO + NiO (1.0 vol. % NiO), 0.25 SiO_2 and 0.01 Al_2O_3; prepared from high purity fused MgO and analytical reagent grade NiO; bulk density 3.12 g cm^{-3} and total porosity 14.7%.	Slip-cast and fired; data corrected to theoretical density.
◇	59-1	579-1468	± 4	Same as above except with 2.8 vol. % NiO; bulk density 3.10 g cm^{-3} and total porosity 18%.	Same as above.
●	59-1	413-1272	± 4	Same as above except with 15 vol. % NiO; bulk density 3.34 g cm^{-3} and total porosity 15%.	Same as above.



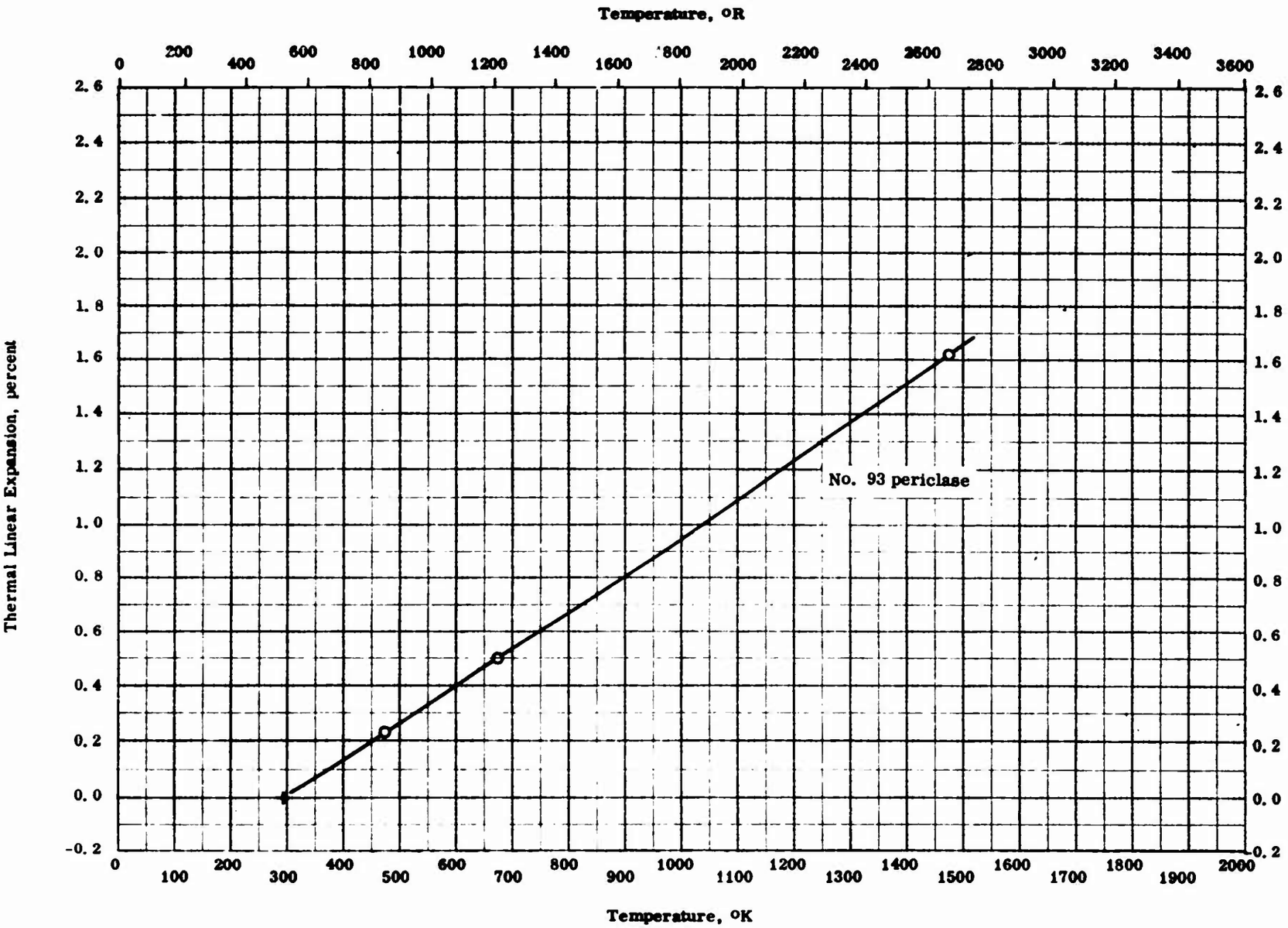
THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + SILICON DIOXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	55-1	623-1153		92.7 MgO and 7.3 SiO_2.	
○	55-3	423-1173		95 MgO and 5 SiO_2.	
△	55-3	423-1123		85 MgO and 15 SiO_2.	
◇	55-3	623-1023		75 MgO and 25 SiO_2.	
▽	55-2	473-1173		65 MgO and 35 SiO_2.	
●	55-4	723-1273	± 8.0	93.88 MgO, 2.08 SiO_2, 1.62 Fe_2O_3, 1.24 CaO, 0.83 Al_2O_3 and 0.05 TiO_2; porosity 22%; density 175 lb ft^{-3}.	

TPRC

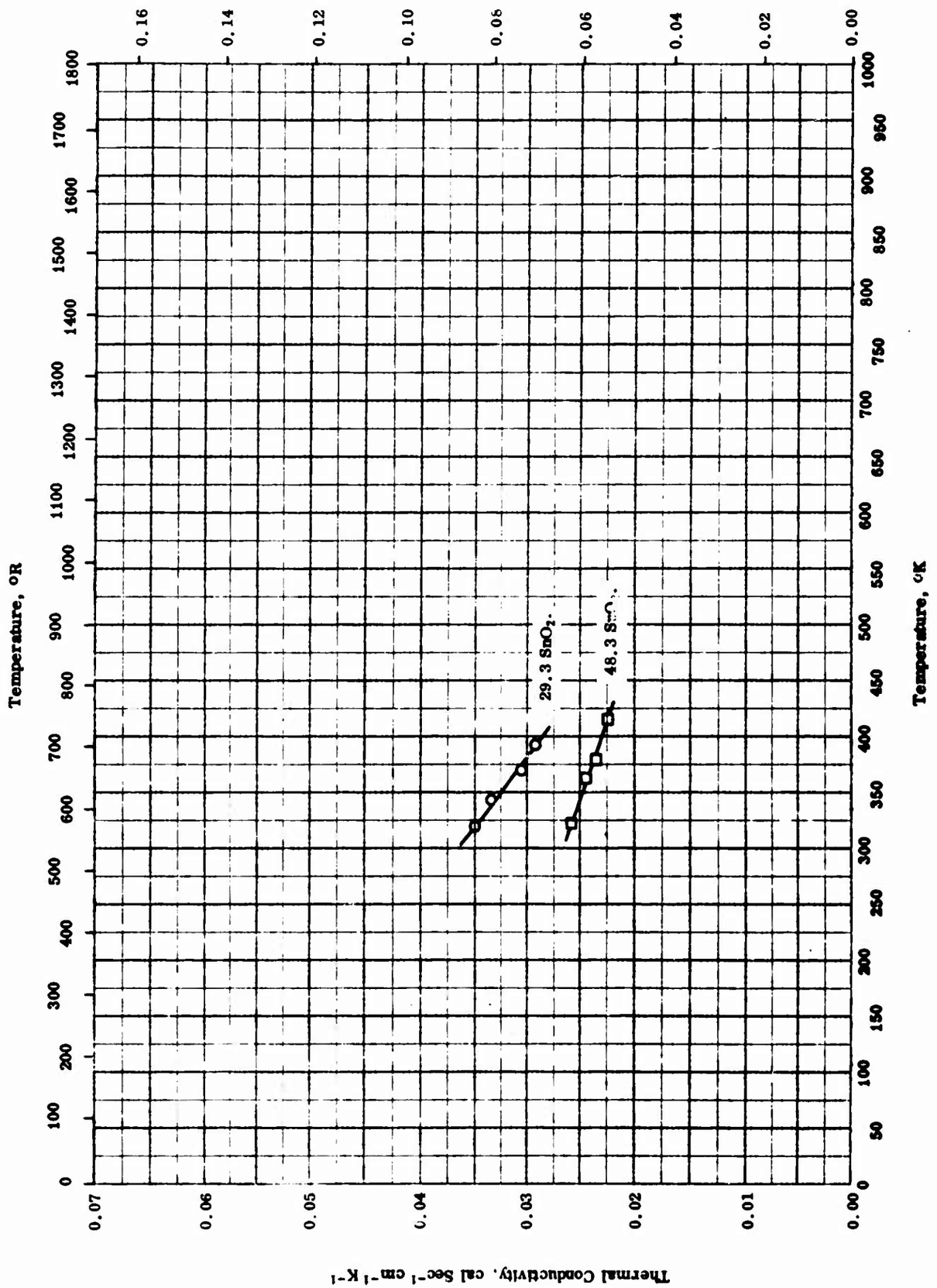


THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE + SILICON DIOXIDE

THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE + SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	46-7	293-1473		97.5 No. 93 periclase (95 MgO and .. 5 SiO_2) and 2.5 sea-water MgO; porosity 31%; density 155 lb ft^{-3}.	Heated at 4 C min^{-1}.

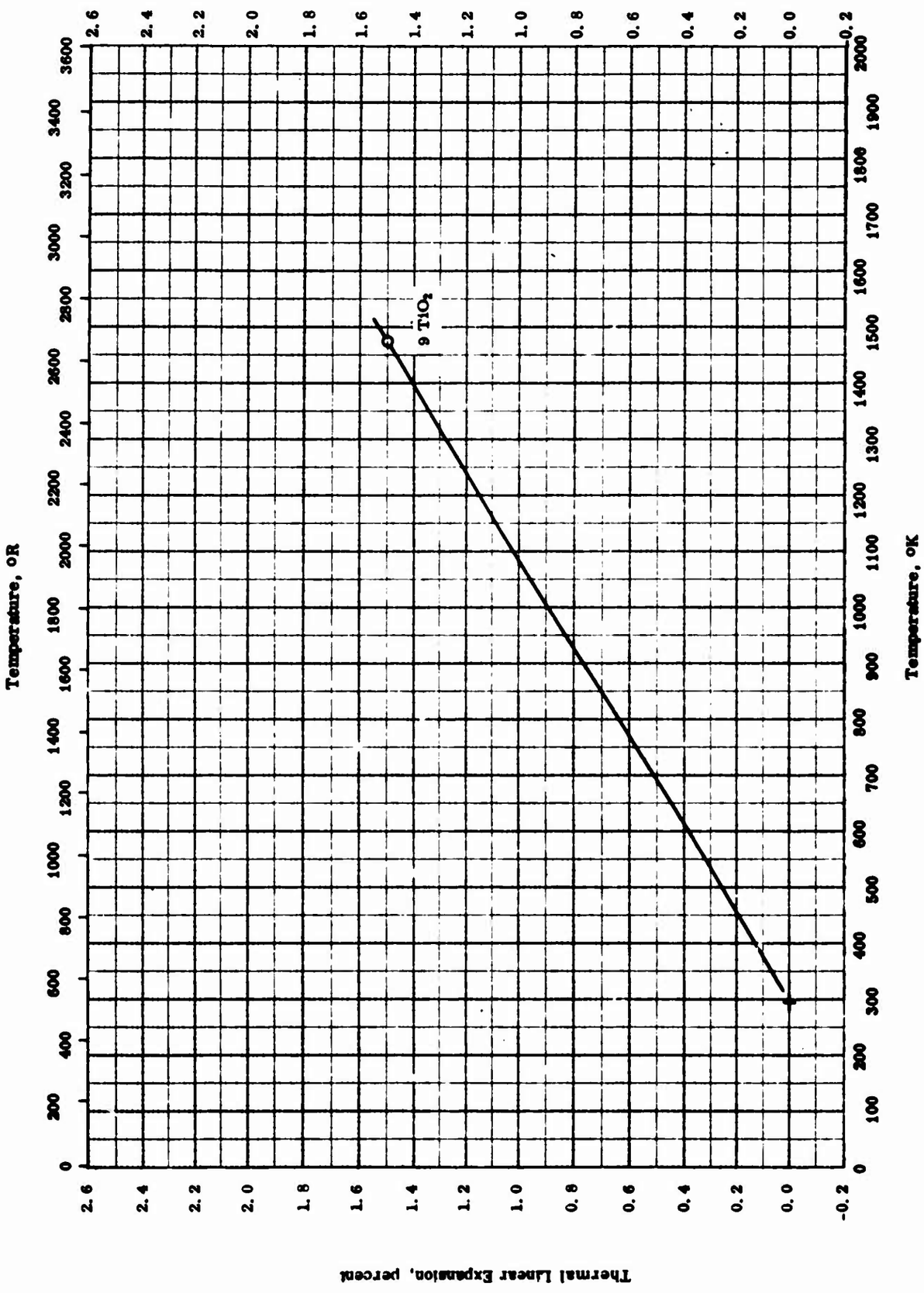


THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + TIN(IC) OXIDE

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + TIN(IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-5	320-392		70.7 MgO and 29.3 SnO_2 (0.17% water absorption); density 240 lb ft^{-3}.	Corresponding to 9 MgO : SnO_2; fired 1.5 hr. at 2800 F; tested in vacuum.
□	53-5	322-415		51.7 MgO and 48.3 SnO_2 (0.028% water absorption); density 261 lb ft^{-3}.	Corresponding to 4 MgO : SnO_2; fired 1.5 hr. at 2700 F; tested in vacuum.



THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE + TITANIUM DIOXIDE

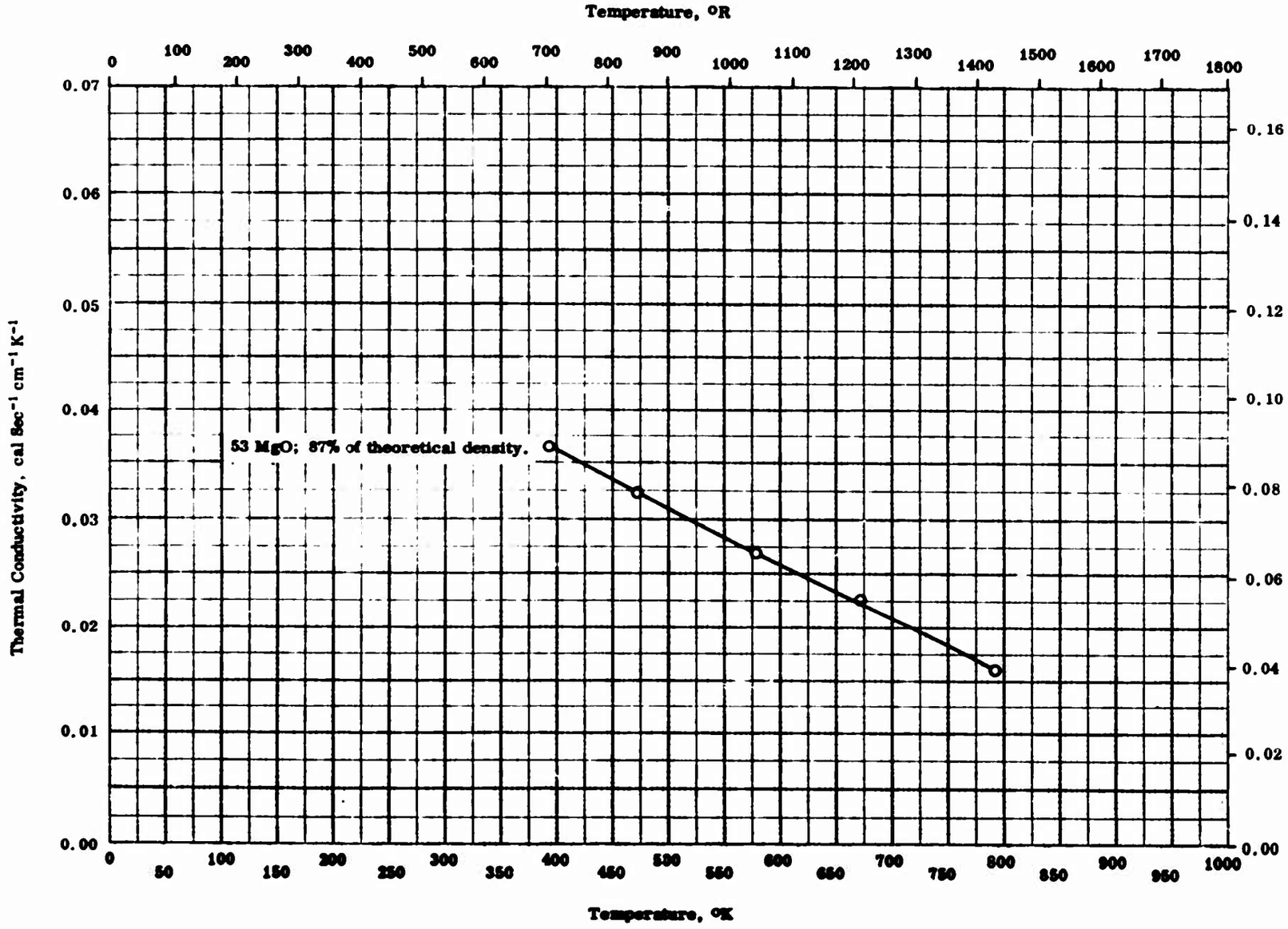
Thermal Linear Expansion, percent

TPRC

THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE + TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	46-7	293-1473		91 MgO and 9 TiO_2.	Heated at 4 C min^{-1}.



THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + URANIUM DIOXIDE

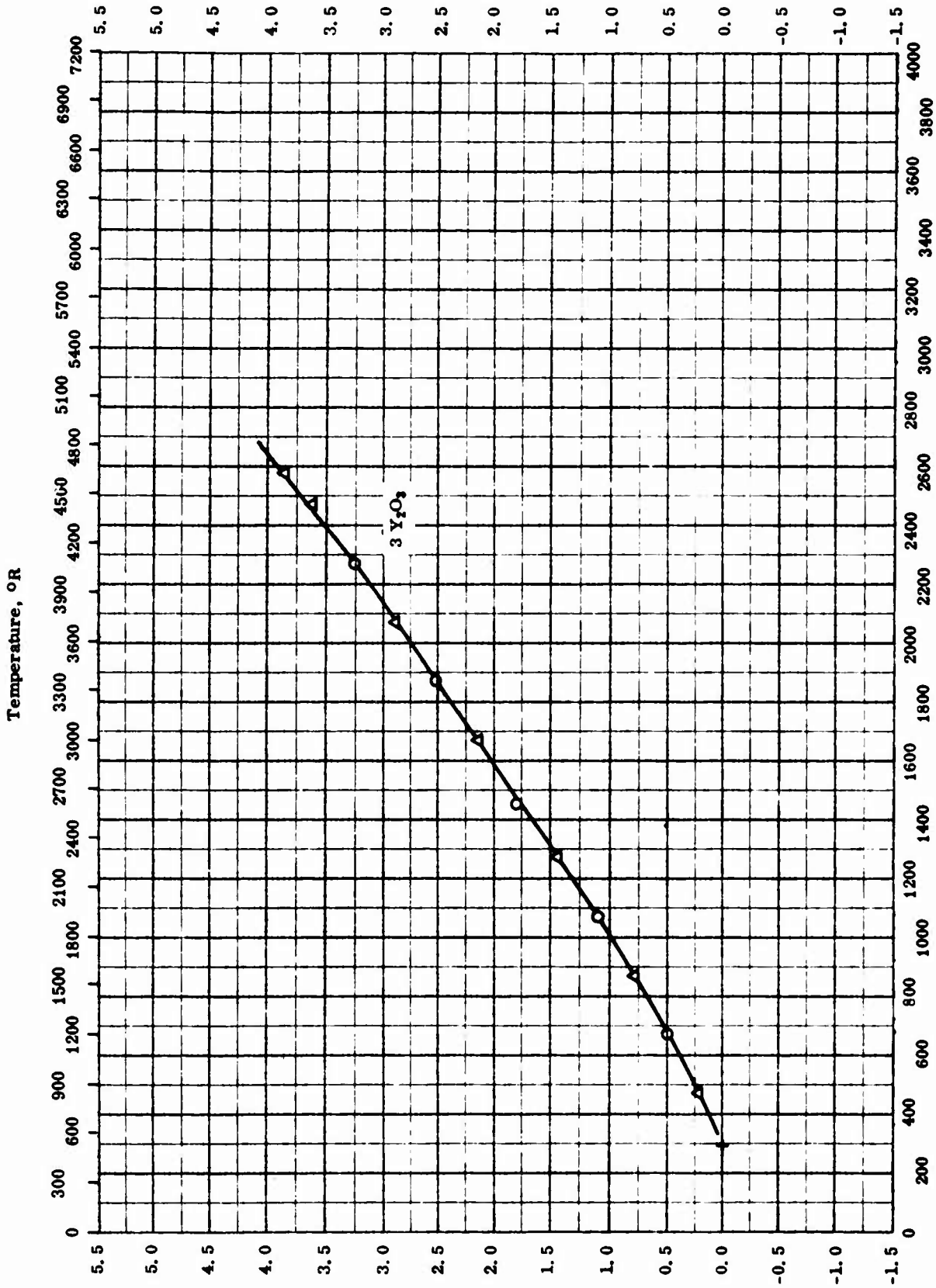
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THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-3	393-793		53 MgO and 47 UO_2; 87% of theoretical density.	Sintered.

Thermal Linear Expansion, percent



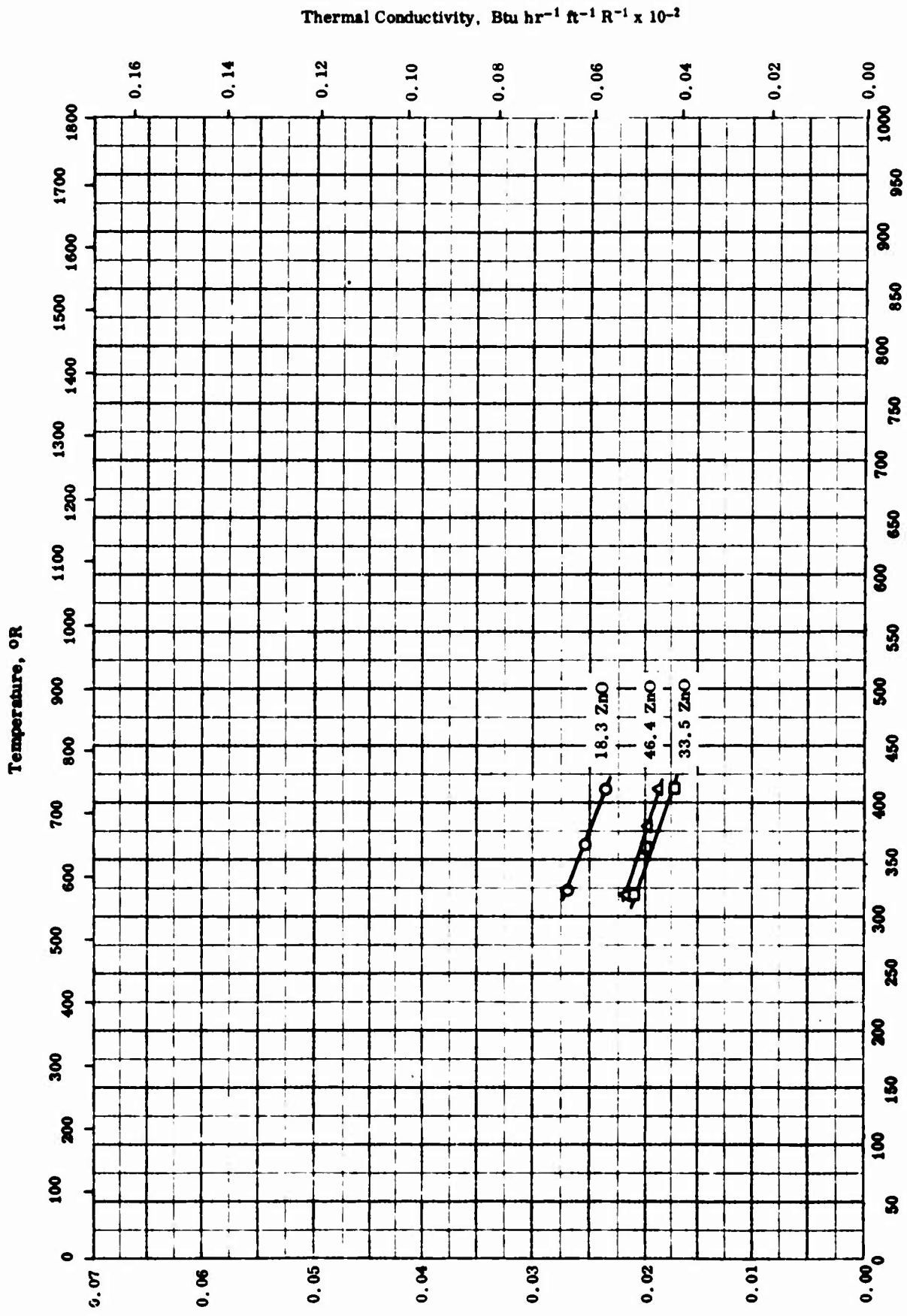
THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE + YTTRIUM OXIDE

THERMAL LINEAR EXPANSION -- MAGNESIUM OXIDE + YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error σc	Sample Specifications	Remarks
Δ	64-28	298-2573		MgO and $3Y_2O_3$; 98 - 99 pure; impurities: Fe, Ca, Si, and Al. [Author's design : LA-11]	Aqueous slip cast; sintered at 1750 C in air; measured in 95 oxygen and 5 nitrogen atm.
O	64-28	298-2473		Same as above. [Author's design : LA-12]	Same as above except measured in 80 - 90 argon, 3 - 4 hydrogen, and 6 - 16 air atm.

THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + ZINC OXIDE

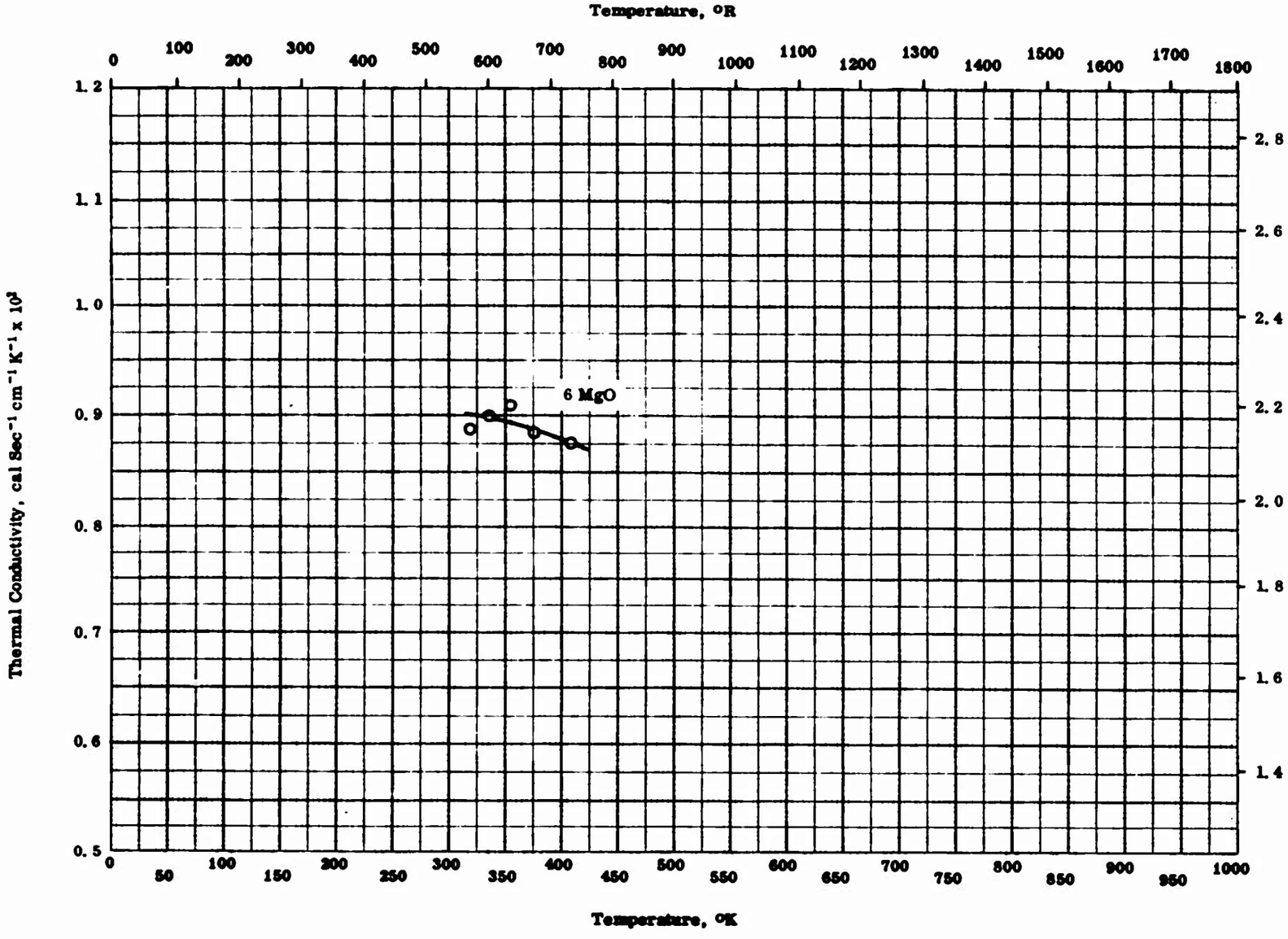


THERMAL CONDUCTIVITY -- MAGNESIUM OXIDE + ZINC OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-6	322-411		81.7 MgO and 18.3 ZnO; density 314.5 lb ft^{-3}.	Corresponding to 9 MgO: ZnO; fired to 2700 F; tested in vacuum.
□	53-6	320-412		66.5 MgO and 33.5 ZnO; density 303.3 lb ft^{-3}.	Corresponding to 4 MgO: ZnO; fired 2 hr. at 2700 F; tested in vacuum.
△	53-6	319-411		53.6 MgO and 46.4 ZnO; density 5.00 g cm^{-3}.	Corresponding to 7 MgO: 3 ZnO; fired 2 hr. at 2700 F; tested in vacuum.

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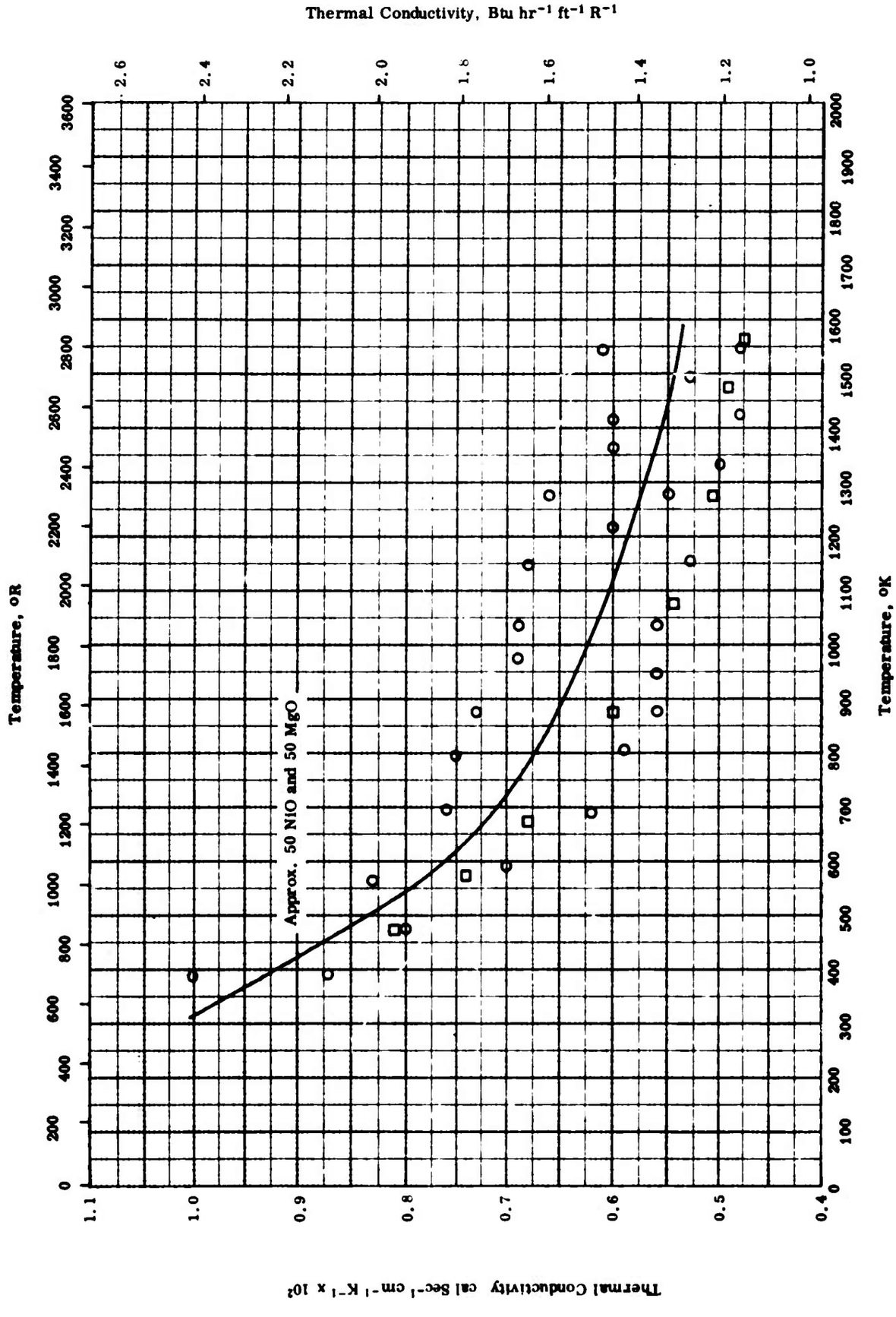


THERMAL CONDUCTIVITY -- MANGANESE SESQUIOXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- MANGANESE SESQUIOXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	52-4	319-408		94 Mn_2O_3 and 6 MgO; density 4.11 g cm^{-3} and 0.960% water absorption.	Corresponding to 4 Mn_2O_3: MgO; firing temperature 2500 F.



THERMAL CONDUCTIVITY -- NICKEL MONOXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- NICKEL MONOXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	54-2	473-1563		50 NiO and 50 MgO.	Data were corrected to zero porosity.
○	59-1	389-1548	± 4	99.5 MgO + NiO (34.5 vol. % NiO), 0.25 SiO_2, and 0.1 Al_2O_3; prepared by high-purity fused MgO with analytical reagent grade NiO; bulk density 3.26 g cm^{-3} and total porosity 30.5%.	Slip-cast and fired; data corrected for theoretical density.

PROPERTIES OF NIOBIUM PENTOXIDE + ALUMINUM OXIDE

REPORTED VALUES

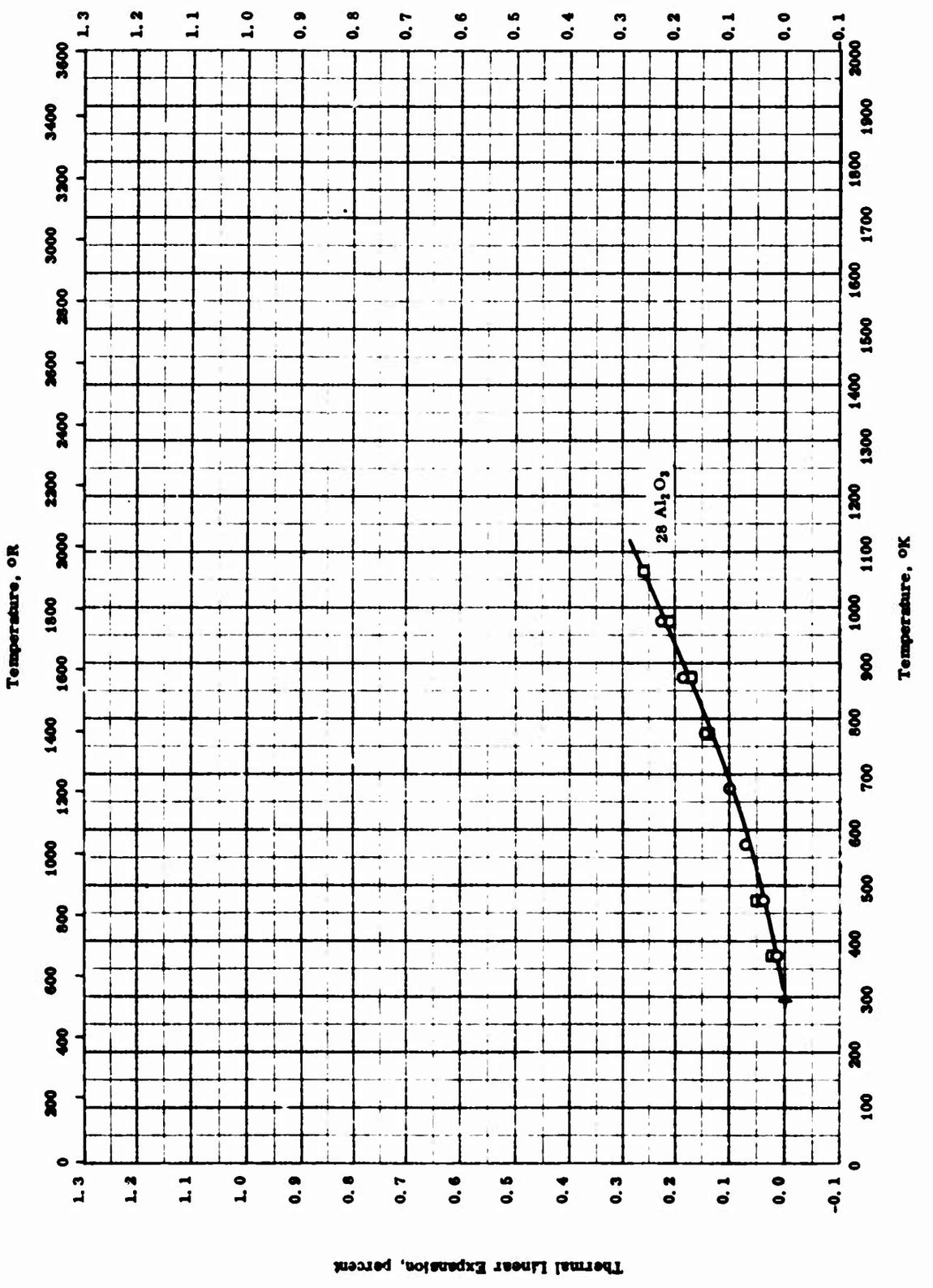
Melting Point		K	R
○	11.22 Al_2O_3.	1718	3093
□	15.93 Al_2O_3.	1728	3111
△	27.48 Al_2O_3.	1773	3192
▽	43.12 Al_2O_3.	1758	3165

PROPERTIES OF NIOBIUM PENTOXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-12	1718		88.78 Nb_2O_5 and 11.22 Al_2O_3; prepared from 99.9 Nb_2O_5 and 99.5 Al_2O_3.	M.P. from observed fusion temperature during sintering.
□	52-12	1728		84.07 Nb_2O_5 and 15.93 Al_2O_3; same as above.	Same as above.
△	52-12	1773		72.59 Nb_2O_5 and 27.48 Al_2O_3; same as above.	Same as above.
▽	52-12	1758		56.88 Nb_2O_5 and 43.12 Al_2O_3; same as above.	Same as above.

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THERMAL LINEAR EXPANSION -- NIOBIUM PENTOXIDE + ALUMINUM OXIDE

THERMAL LINEAR EXPANSION -- NIOBIUM PENTOXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	52-22	293-973		72.3 Nb_2O_5 and 27.7 Al_2O_3 (corresponds to $Al_2O_3 \cdot Nb_2O_5$); prepared from c.p. raw materials (major impurity Ta_2O_5).	Calcined 2 hrs at 1200 C and fired at 1480 C.
□	52-12	293-1163		72.3 Nb_2O_5 and 27.7 Al_2O_3 (corresponds to $Al_2O_3 \cdot Nb_2O_5$).	Fired 2 hrs at 1450 C and cooled in 24 hrs.

PROPERTIES OF NIOBIUM PENTOXIDE + BERYLLIUM OXIDE

REPORTED VALUES

Melting Point		K	R
○	2.48 BeO.	1643	2958
□	3.28 BeO.	1643	2958
△	4.84 BeO.	1713	3084
▽	9.23 BeO.	1718	3094
◁	16.89 BeO.	1713	3084
▷	23.37 BeO.	1723	3102
◇	28.91 BeO.	1723	3102

PROPERTIES OF NIOBIUM PENTOXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-12	1643		97.52 Nb_2O_5 and 2.48 BeO; prepared from 99.9 Nb_2O_5 and 99.5 BeO.	M.P. from observed fusion temperature during sintering.
□	52-12	1643		96.72 Nb_2O_5 and 3.28 BeO; same as above.	Same as above.
△	52-12	1713		95.16 Nb_2O_5 and 4.84 BeO; same as above.	Same as above.
▽	52-12	1718		90.77 Nb_2O_5 and 9.23 BeO; same as above.	Same as above.
◁	52-12	1713		83.01 Nb_2O_5 and 16.89 BeO; same as above.	Same as above.
▷	52-12	1723		76.63 Nb_2O_5 and 23.37 BeO; same as above.	Same as above.
◇	52-12	1723		71.09 Nb_2O_5 and 28.91 BeO; same as above.	Same as above.

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PROPERTIES OF NIOBIUM PENTOXIDE + MAGNESIUM OXIDE

REPORTED VALUES

Melting Point		K	R
○	3.65 MgO.	1708	3075
□	4.81 MgO.	1698	3057
△	7.05 MgO.	1708	3075
▽	13.17 MgO.	1758	3165
◁	30.34 MgO.	1798	3237
▷	31.27 MgO.	1818	3273
◇	37.76 MgO.	1823	3282

PROPERTIES OF NIOBIUM PENTOXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-12	1708		96.35 Nb_2O_5 and 3.65 MgO; prepared from 99.9 Nb_2O_5 and 99.5 MgO.	M.P. from observed fusion temperature during sintering.
□	52-12	1698		95.19 Nb_2O_5 and 4.81 MgO; same as above.	Same as above.
△	52-12	1708		92.95 Nb_2O_5 and 7.05 MgO; same as above.	Same as above.
▽	52-12	1758		86.83 Nb_2O_5 and 13.17 MgO; same as above.	Same as above.
◁	52-12	1798		69.66 Nb_2O_5 and 30.34 MgO; same as above.	Same as above.
▷	52-12	1818		68.73 Nb_2O_5 and 31.27 MgO; same as above.	Same as above.
◇	52-12	1823		62.24 Nb_2O_5 and 37.76 MgO; same as above.	Same as above.

PROPERTIES OF NIOBIUM PENTOXIDE + TITANIUM DIOXIDE

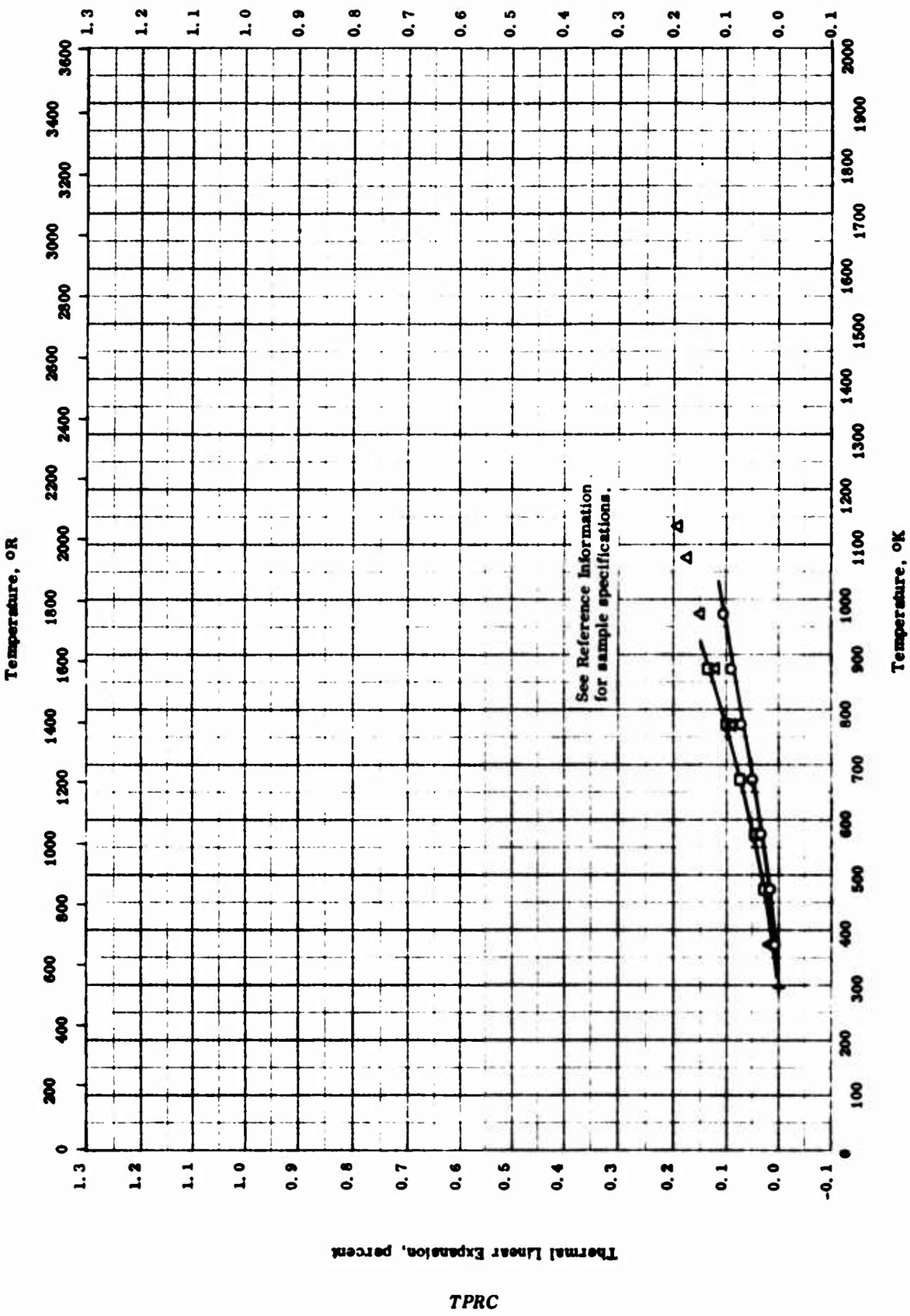
REPORTED VALUES

Melting Point		K	R
○	10.73 TiO_2.	1758	3165
□	13.81 TiO_2.	1743	3138
△	19.38 TiO_2.	1718	3093
▽	32.47 TiO_2.	1748	3147
◇	49.02 TiO_2.	1768	3183

PROPERTIES OF NIOBIUM PENTOXIDE + TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error σ%	Sample Specifications	Remarks
○	52-12	1758		89.27 Nb_2O_5 and 10.73 TiO_2; prepared from 99.9 Nb_2O_5 and 99.5 TiO_2.	M.P. from observed fusion temperature during sintering.
□	52-12	1743		86.19 Nb_2O_5 and 13.81 TiO_2; same as above.	Same as above.
△	52-12	1718		80.62 Nb_2O_5 and 19.38 TiO_2; same as above.	Same as above.
▽	52-12	1748		67.53 Nb_2O_5 and 32.47 TiO_2; same as above.	Same as above.
◇	52-12	1768		50 98 Nb_2O_5 and 49.02 TiO_2; same as above.	Same as above.



THERMAL LINEAR EXPANSION -- NIOBIUM PENTOXIDE + TITANIUM DIOXIDE

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THERMAL LINEAR EXPANSION -- NIOBIUM PENTOXIDE + TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-22	293-973		76.9 Nb_2O_5 and 23.1 TiO_2 (corresponds to $TiO_2 \cdot Nb_2O_5$); prepared from c.p. raw materials (Ta_2O_5 major impurity).	Calcined 2 hrs at 1120 C and fired at 1400 C.
□	52-22	293-973		62.5 Nb_2O_5 and 37.5 TiO_2 (corresponds to $TiO_2 \cdot Nb_2O_5 + TiO_2$); prepared from c.p. raw materials (Ta_2O_5 major impurity).	Same as above.
△	52-12	293-1133		76.9 Nb_2O_5 and 23.1 TiO_2.	Fired 2 hrs at 1450 C and cooled in 24 hrs.

PROPERTIES OF NIOBIUM PENTOXIDE + ZIRCONIUM DIOXIDE

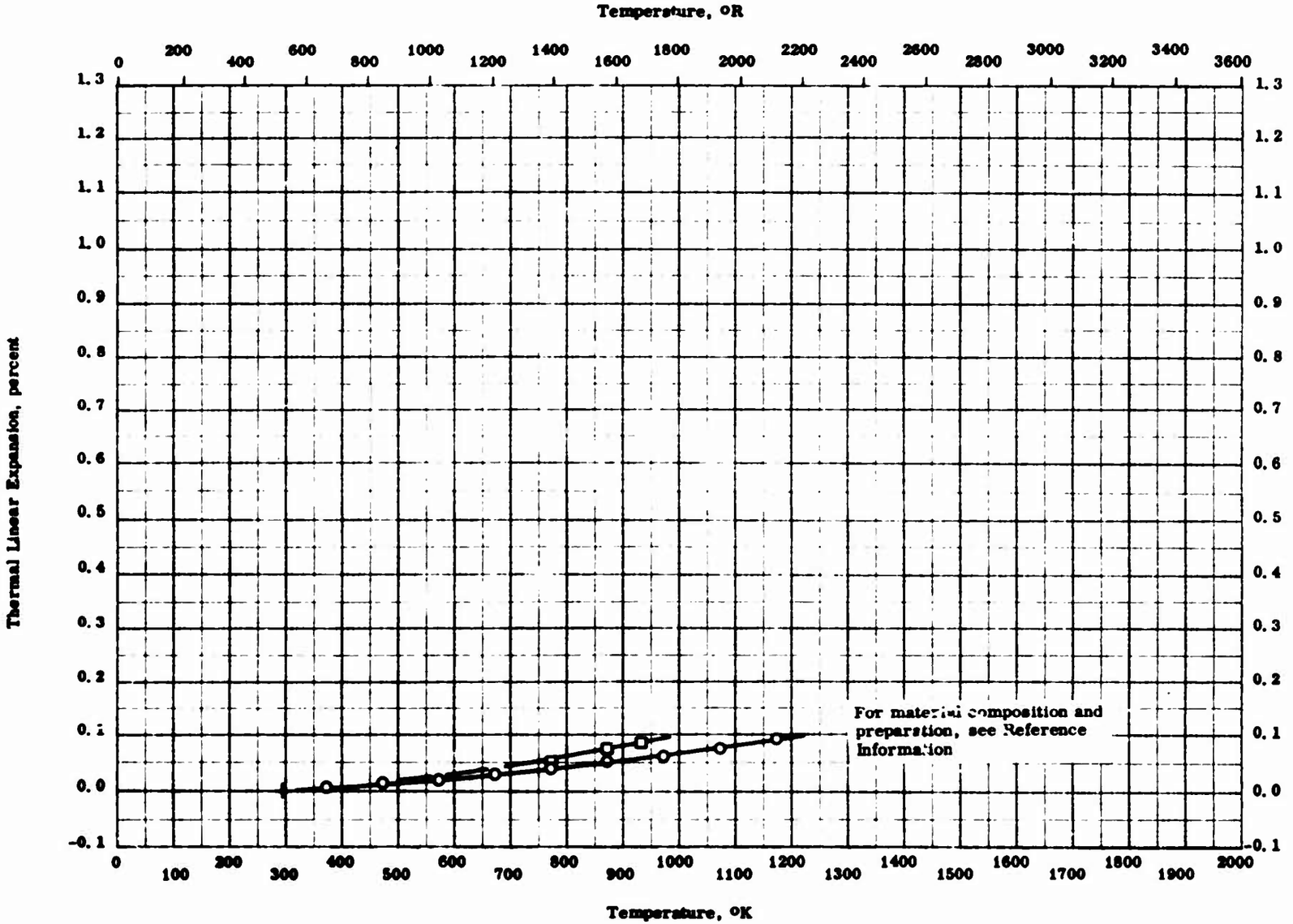
REPORTED VALUES

Melting Point		K	R
○	16.78 ZrO_2.	1708	3075
□	21.19 ZrO_2.	1708	3075
△	28.74 ZrO_2.	1683	3030
▽	44.65 ZrO_2.	1728	3111
◁	33.2 ZrO_2.	1728	3111
▷	49.9 ZrO_2.	1784	3228

PROPERTIES OF NIOBIUM PENTOXIDE + ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-12	1708		83.22 Nb_2O_5 and 16.78 ZrO_2; prepared from 99.9 Nb_2O_5 and 99.5 ZrO_2.	M.P. from observed fusion temperature during sintering.
□	52-12	1708		78.81 Nb_2O_5 and 21.19 ZrO_2; same as above.	Same as above.
△	52-12	1683		71.26 Nb_2O_5 and 28.74 ZrO_2; same as above.	Same as above.
▽	52-12	1728		55.35 Nb_2O_5 and 44.65 ZrO_2; same as above.	Same as above.
◁	52-12	1728		66.8 Nb_2O_5 and 33.2 ZrO_2; same as above.	Same as above.
▷	52-12	1784		50.1 Nb_2O_5 and 49.9 ZrO_2; same as above.	Same as above.

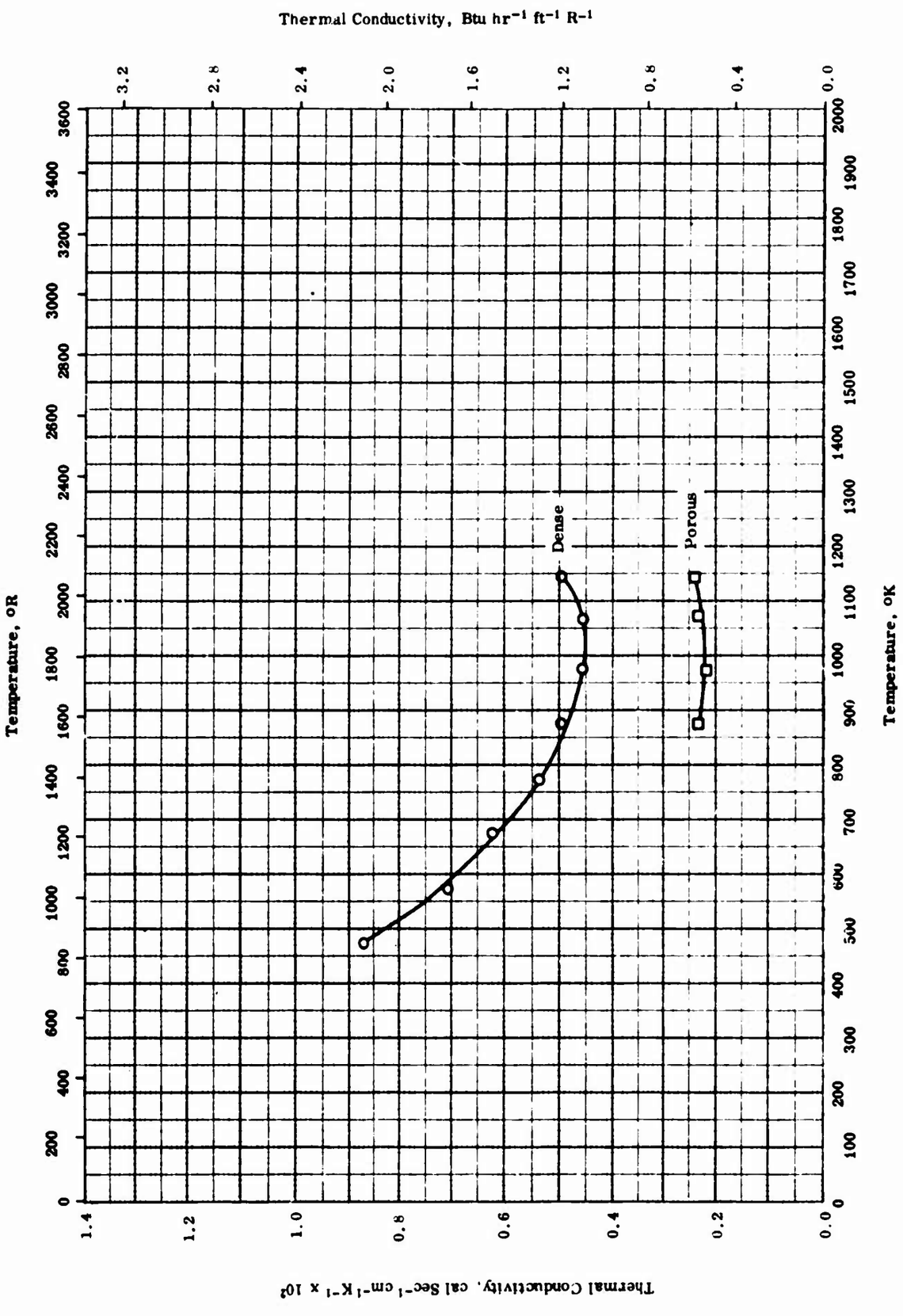


THERMAL LINEAR EXPANSION -- NIOBIUM PENTOXIDE + ZIRCONIUM DIOXIDE

THERMAL LINEAR EXPANSION -- NIOBIUM PENTOXIDE + ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	52-12	293-1173		86.6 Nb_2O_5 and 13.4 ZrO_2 (corresponds to 3 $Nb_2O_5 + ZrO_2$).	Fired 2 hrs at 1400 C and cooled in 24 hrs.
□	52-22	293-933		86.6 Nb_2O_5 and 13.4 ZrO_2 (corresponds to 3 $Nb_2O_5 + ZrO_2$, a form of stabilized Zirconia); prepared from c.p. raw materials (major impurity Ta_2O_5); apparent porosity 15 %.	Calcined 2 hrs at 1065 C and fired at 1345 C.



THERMAL CONDUCTIVITY -- SAMARIUM SESQUIOXIDE + GADOLINIUM OXIDE

THERMAL CONDUCTIVITY -- SAMARIUM SESQUIOXIDE + GADOLINIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	55-3	473-1148		Dense; solid solution.	Fired to dense condition.
□	55-3	873-1143		Quite porous; solid solution.	Fired to lower temp.

PROPERTIES OF SAMARIUM SESQUIOXIDE + GADOLINIUM OXIDE + DYSPROSIUM OXIDE + YTTRIUM OXIDE

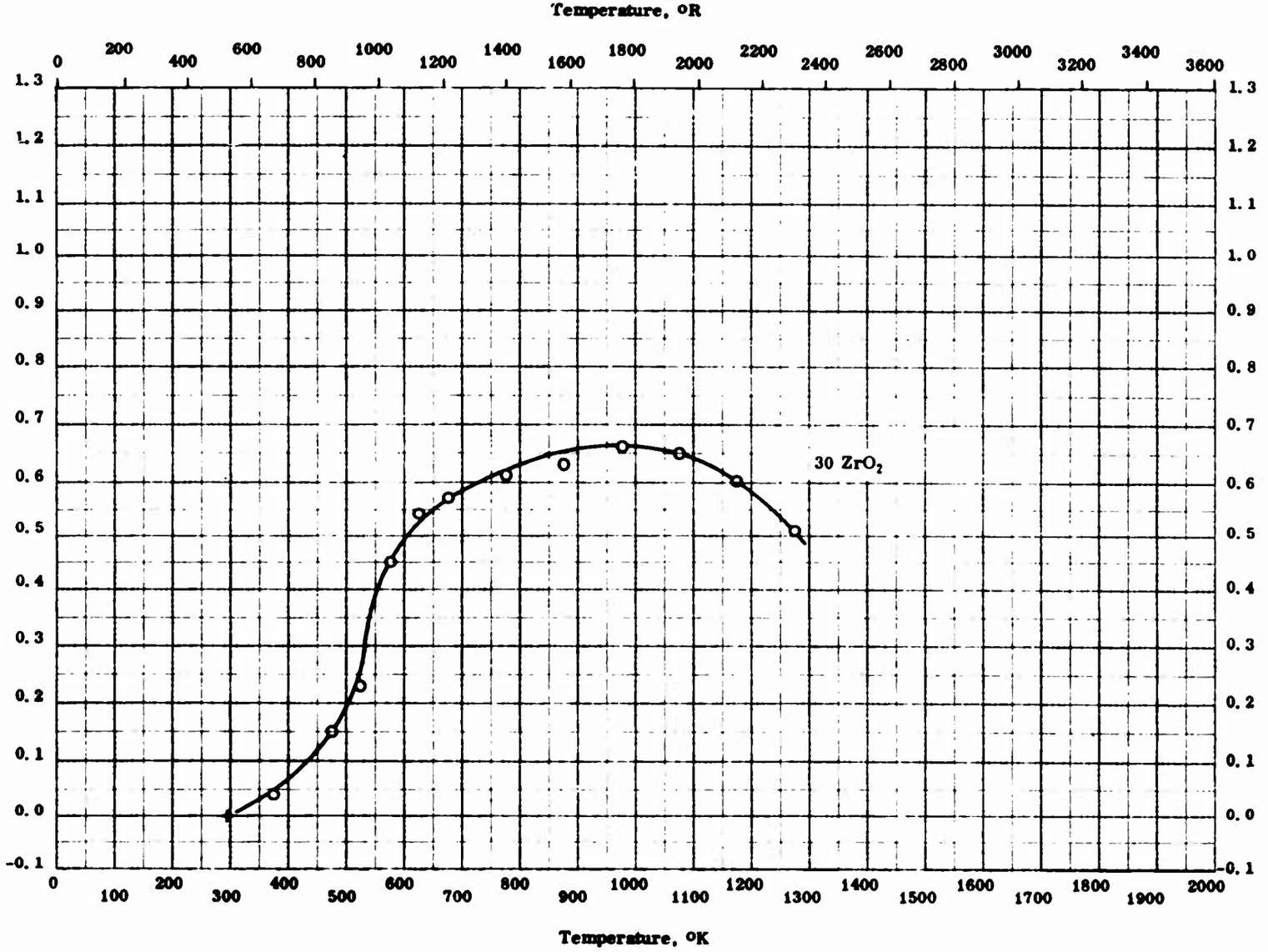
REPORTED VALUES

Density		g cm^{-3}	lb ft^{-3}
O	26.3 Gd_2O_3, 4.8 Dy_2O_3 and 4.2 Y_2O_3.	6.60	412

PROPERTIES OF SAMARIUM SESQUIOXIDE + GADOLINIUM OXIDE + DYSPROSIUM OXIDE + YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-8	298		63.8 Sm_2O_3, 26.3 Gd_2O_3, 4.8 Dy_2O_3, 4.2 Y_2O_3, 0.9 Nd_2O_3, and other rare earth oxides.	Lindsay commercial mixture; 1/4 of mixture pre-calcined at 1400 C, all dry pressed at 4000 psi, and sintered at 1500 C.



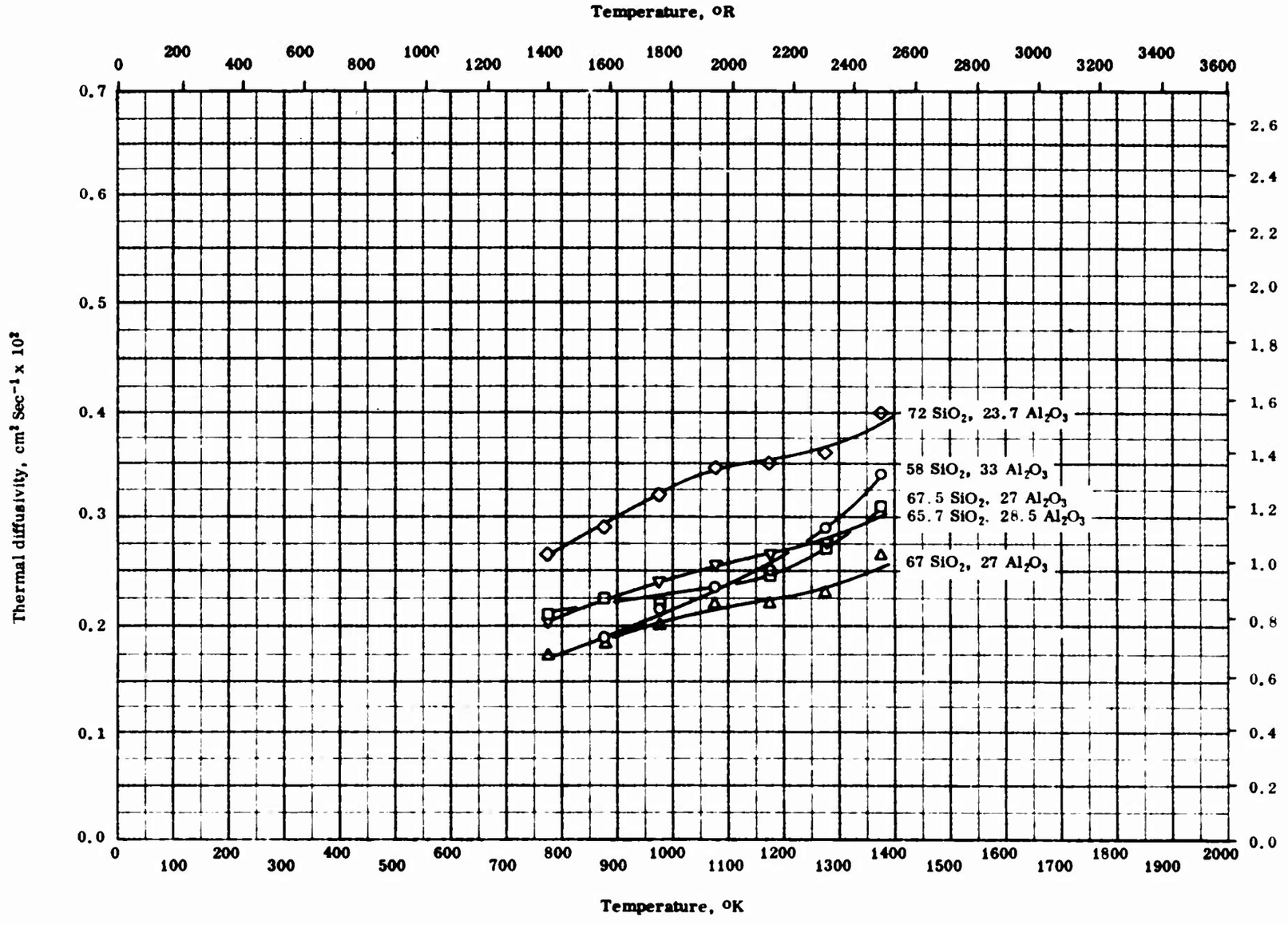
THERMAL LINEAR EXPANSION -- PHOSPHORUS PENTOXIDE + ZIRCONIUM DIOXIDE

THERMAL LINEAR EXPANSION - PHOSPHORUS PENTOXIDE + ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-35	293-1273		$ZrO_2 + 2\ P_2O_5$; 30.3 ZrO_2 and 69.7 P_2O_5.	Calcined 10 hrs at 1300 C.

TPRC



THERMAL DIFFUSIVITY -- SILICON DIOXIDE + ALUMINUM OXIDE

TPRC

THERMAL DIFFUSIVITY -- SILICON DIOXIDE + ALUMINUM OXIDE

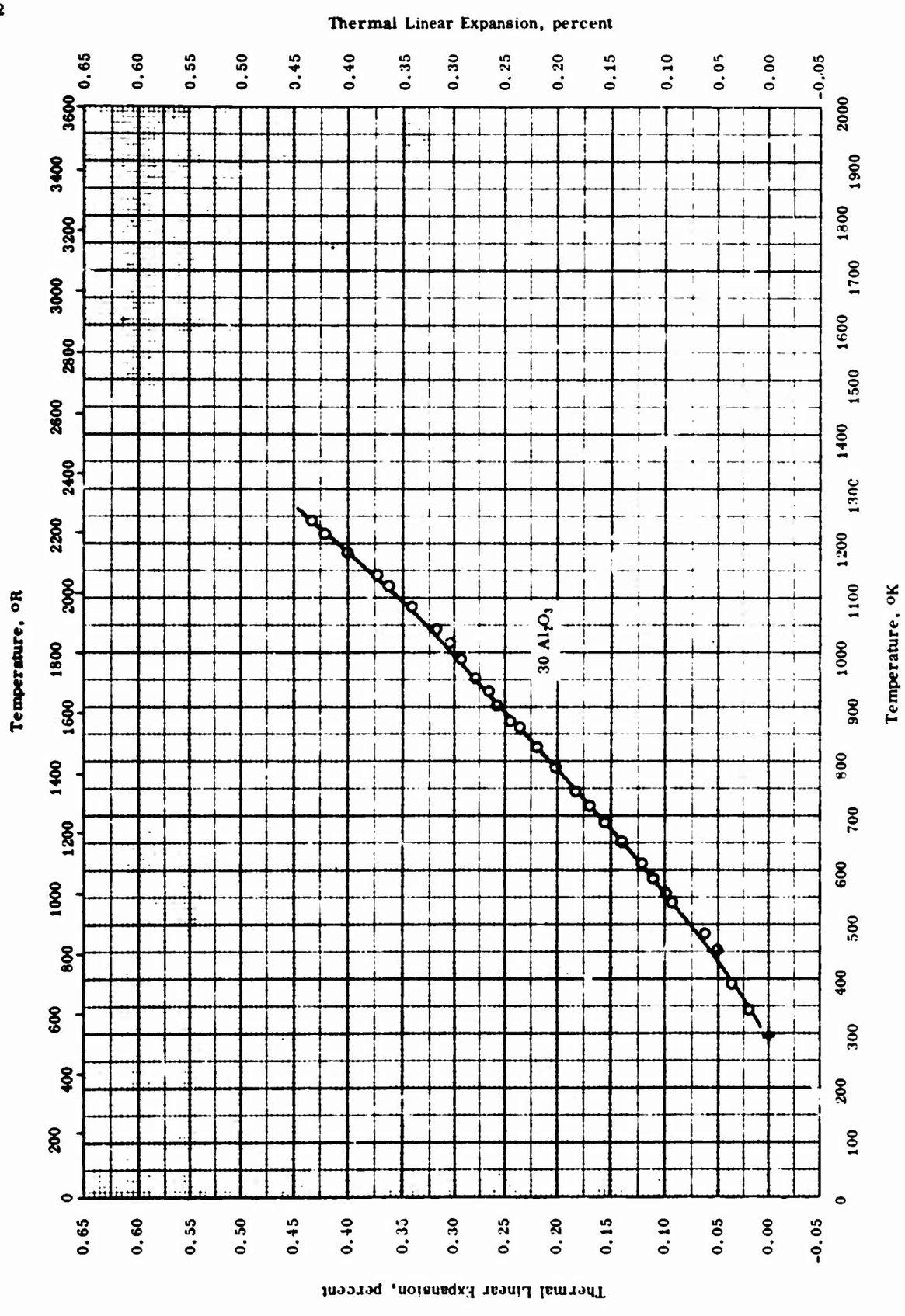
REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	21-1	873-1373		Firebrick E; 57.9 SiO_2 and 32.96 Al_2O_3; very close structure, abundance of fine grained rounded grog and a little larger grained grog detected; adherence exceptionally good, marked by a fair number of black cores, generally with cavities; faces smooth and edge sharp; porosity 15.9% and true specific gravity 2.36; sample dimensions 9 by 4 1/2 by 2 1/2 in.	Heat flow in lengthwise direction.
□	21-1	773-1373		Firebrick F; 67.49 SiO_2 and 27.15 Al_2O_3; very open texture, abundance of rounded clay grog of uneven grading, some grains approximating to pebbles and unweathered pellets detected; adherence poor, material very firable and highly fissured; 24.6% porosity and 2.55 true specific gravity; sample dimensions 9 by 4 1/2 by 2 1/2 in.	Heat flow in lengthwise direction.
△	21-1	773-1373		Retort material G; 67.10 SiO_2 and 27.17 Al_2O_3; very open texture, very heavily grogged with medium to fine rounded material of uneven grading; abundance of small fissure; adherence of grog very poor and matrix appeared to have contracted away from the grog; 24.5 porosity and 2.45 true specific gravity; sample dimension 9 by 4 1/2 by 2 1/2 in.	Heat flow in lengthwise direction.

(Continued onto next page)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▽	21-1	773-1373		Retort material H; 65.70 SiO_2 and 28.47 Al_2O_3; somewhat closer in texture than the above sample G and heavily grogged with round material of slightly more even grading than the above sample G; adherence as a whole fairly good, although some grains are easily detected; some fissures and very white color with well defined skin; 28.2% porosity and 2.62 true specific gravity; sample dimension 9 by 4 1/2 by 2 1/2 in.	Heat flow in lengthwise direction.
◇	21-1	773-1373		Retort material I; 72.46 SiO_2 and 23.65 Al_2O_3; very close in texture; abundant grog, which tending to be rounded is evenly graded, and possibly some quartz fragments; black core present, but scarce, tendency towards layering; fissure, present but scarce; parallel to outside faces; superficial skin; signs of possible reduction towards end of fire; 21.7% porosity and 2.54 true specific gravity; sample dimensions 9 by 4 1/2 by 2 1/2 in.	Heat flow in lengthwise direction.

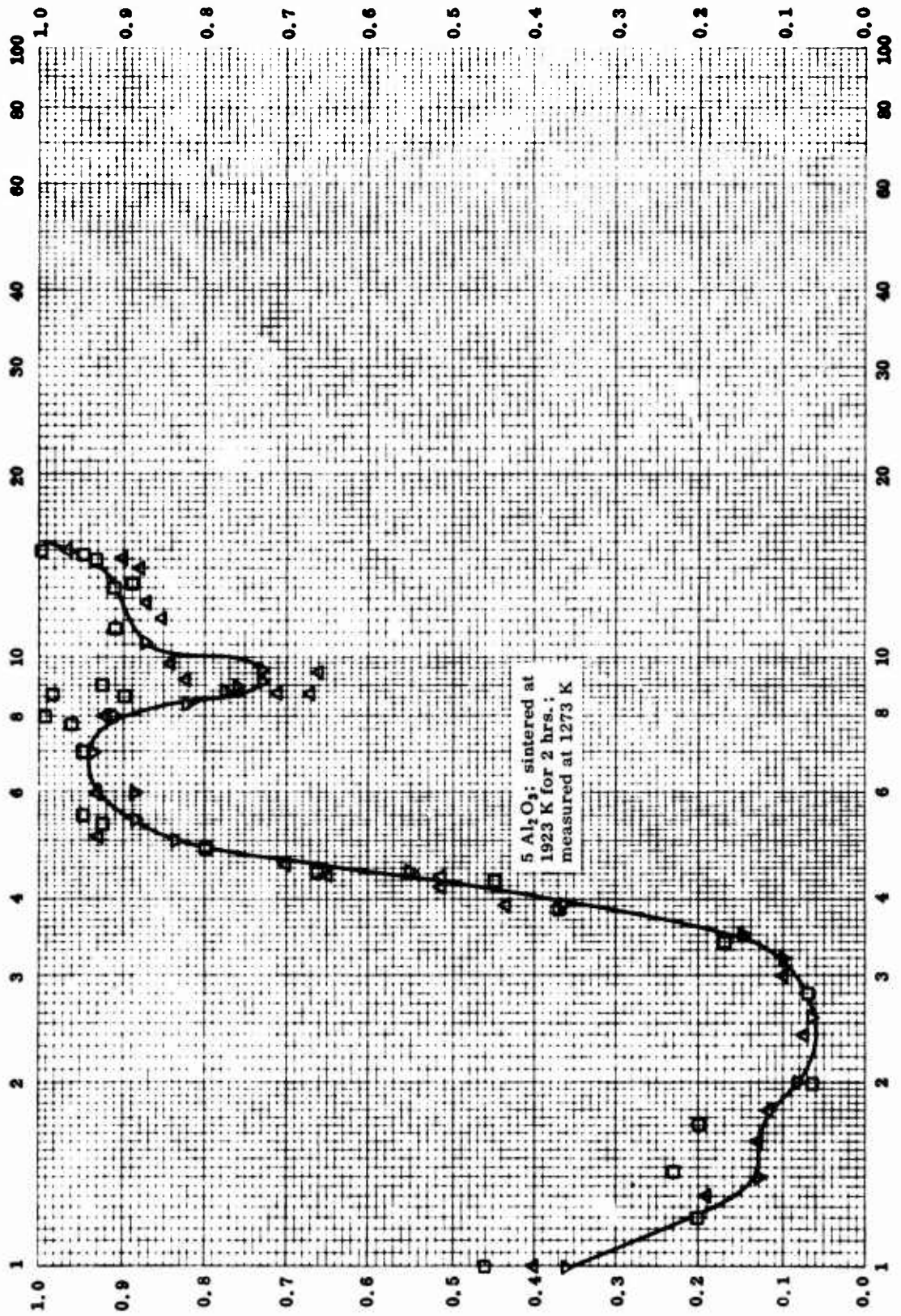


THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE

THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Reprt. Errc. %	Sample Specifications	Remarks
O	61-37	298-1241		64.6 SiO_2, 30.8 Al_2O_3, 2.00 K_2O, 1.58 Na_2O, 0.49 CaO, 0.35 Fe_2O_3, and 0.18 MgO; PC-15 chemical porcelain from McDanel Refractory Porcelain Co., Beaver Falls, Pa.; apparent porosity 0.0%.	Fabricated under commerical conditions, slip-cast, and fired to cone 15 down in 8 1/2 to 10 hrs.

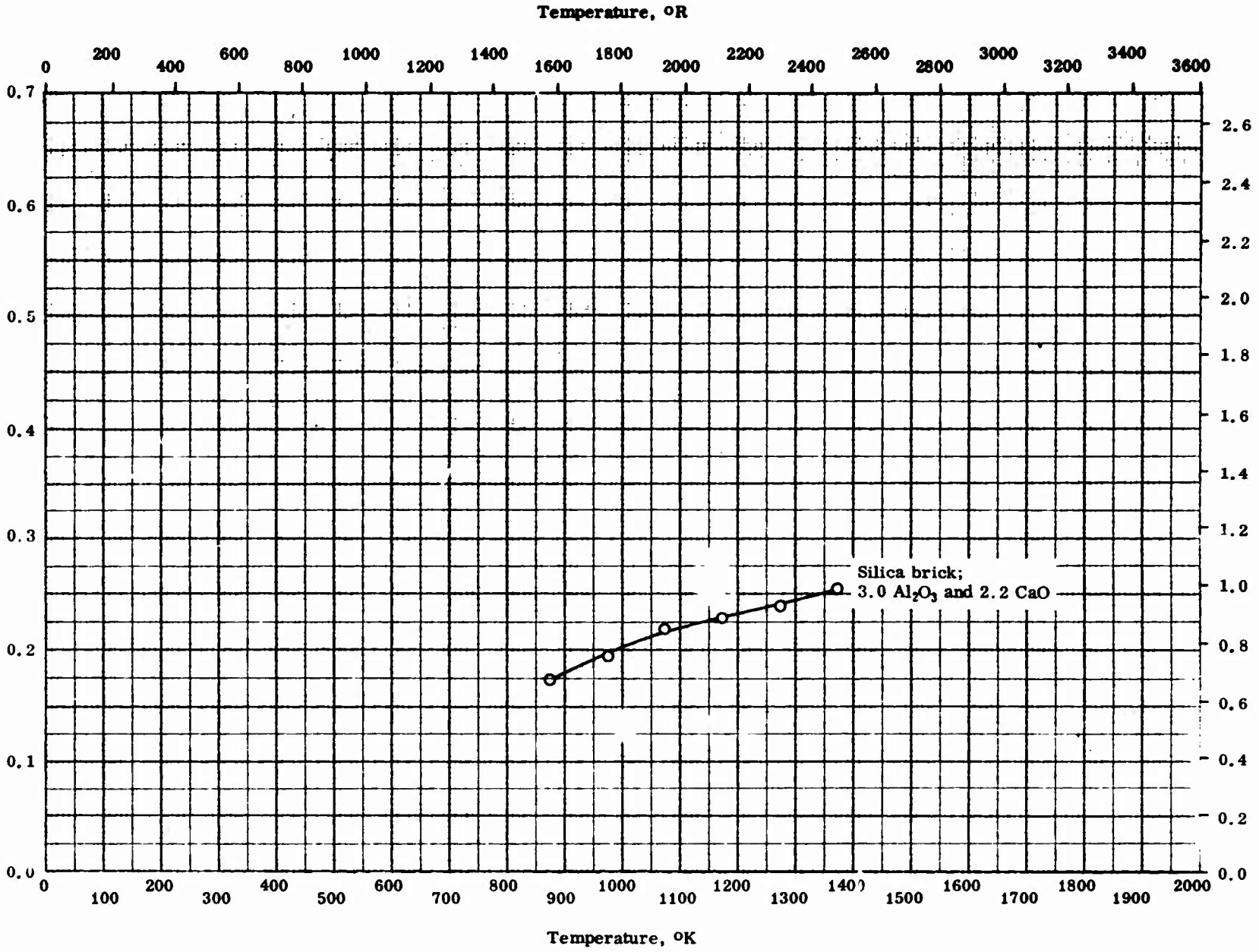


NORMAL SPECTRAL EMITTANCE -- SILICON DIOXIDE + ALUMINUM OXIDE

NORMAL SPECTRAL EMITTANCE -- SILICON DIOXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. ° K	Wavelength Range, μ	Rept. Error%	Sample Specifications	Remarks
□	62-23	1273	1-15		80 SiO_2 and 20 Al_2O_3, alpha-cristobalite and small amount mullite, 0.034 in. thick plate.	Sintered at 1823 K for 1 hr; measured in air; data taken from smooth curve.
△	62-23	1273	1-15		90 SiO_2 and 10 Al_2O_3, alpha-cristobalite, 0.034 in. thickness plate.	Same as above.
▽	62-23	1273	1015		95 SiO_2 and 5 Al_2O_3, alpha-cristobalite, 0.034 in. thickness plate.	Same as above.



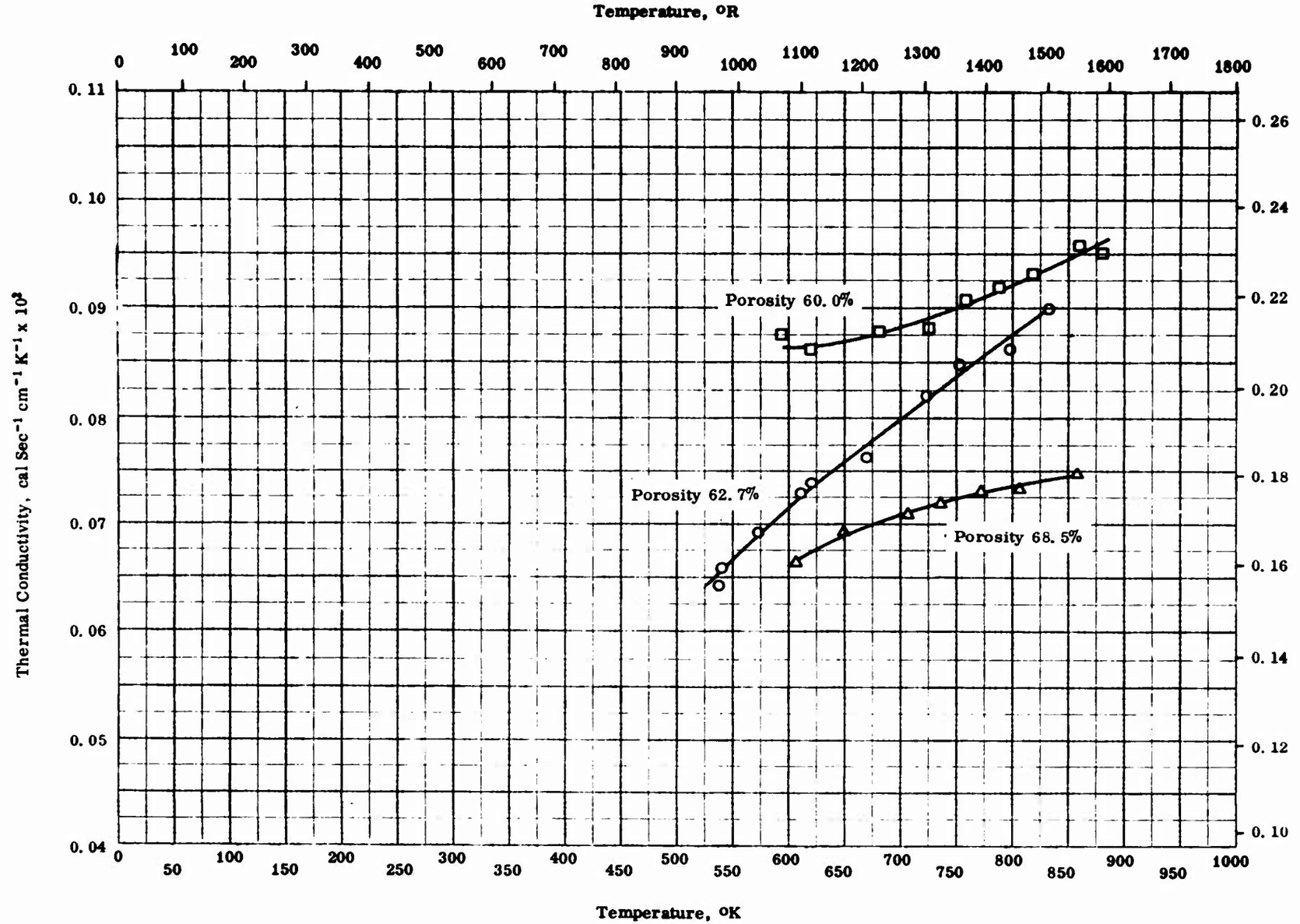
THERMAL DIFFUSIVITY -- SILICON DIOXID . + ALUMINUM OXIDE + CALCIUM OXIDE

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THERMAL DIFFUSIVITY -- SILICON DIOXIDE + ALUMINUM OXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	21-1	873-1373		Silica brick; 93.36 SiO_2, 2.97 Al_2O_3, and 2.2 CaO; texture fairly open and large proportion of angular rock fragments, which vary in size from 1/4 in. downwards; bonding of coarse and fine fairly good; fine material, easily detached and large numbers of fissures of appreciable size; porosity 20.7% and true specific gravity 2.32; sample dimensions 9 by 4 1/2 by 2 1/2 in.	Heat flow in lengthwise direction.



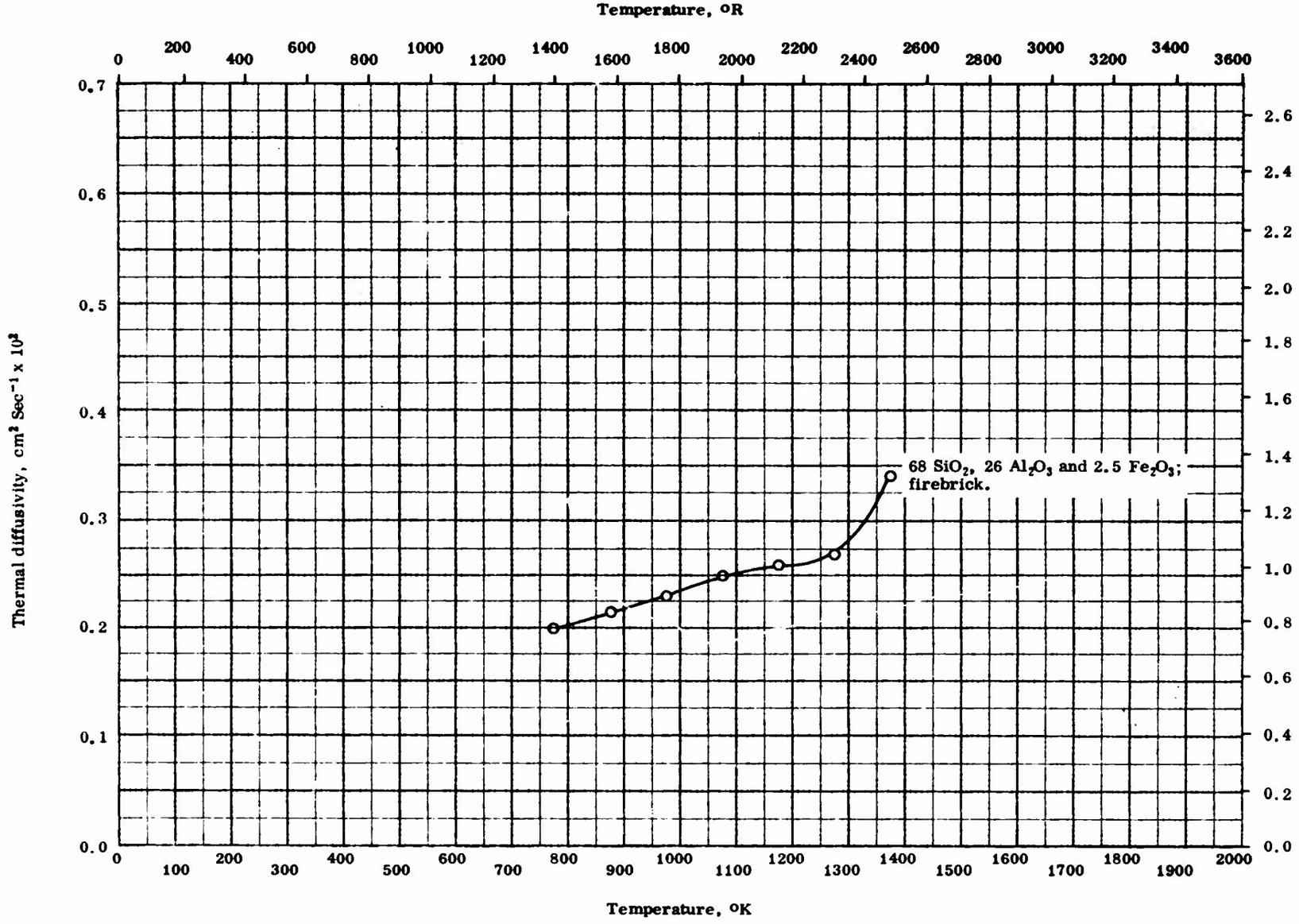
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THERMAL CONDUCTIVITY -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON(IC) OXIDE

THERMAL CONDUCTIVITY -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON(IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	56-1	531-833		Egyptian Fire Brick; 64.5 SiO_2, 26.0 Al_2O_3, 7.0 Fe_2O_3, 1.840 TiO_2, 1.24 Alkali, 1.1 CaO, and 0.6 Mgo; bulk density 63.0 lb ft^{-3} and apparent porosity 62.7%.	
□	56-1	593-881		Egyptian Fire Brick; 65.3 SiO_2, 29.5 Al_2O_3, 3.5 Fe_2O_3, 0.9 MgO, and 0.8 CaO; bulk density 68.0 lb ft^{-3} and apparent porosity 60.0%.	
△	56-1	606-858		Egyptian Fire Brick; 71 SiO_2, 24.0 Al_2O_3, 2.5 Fe_2O_3, 0.8 CaO, and 0.7 MgO; bulk density 48.7 lb ft^{-3} and apparent porosity 68.5%.	



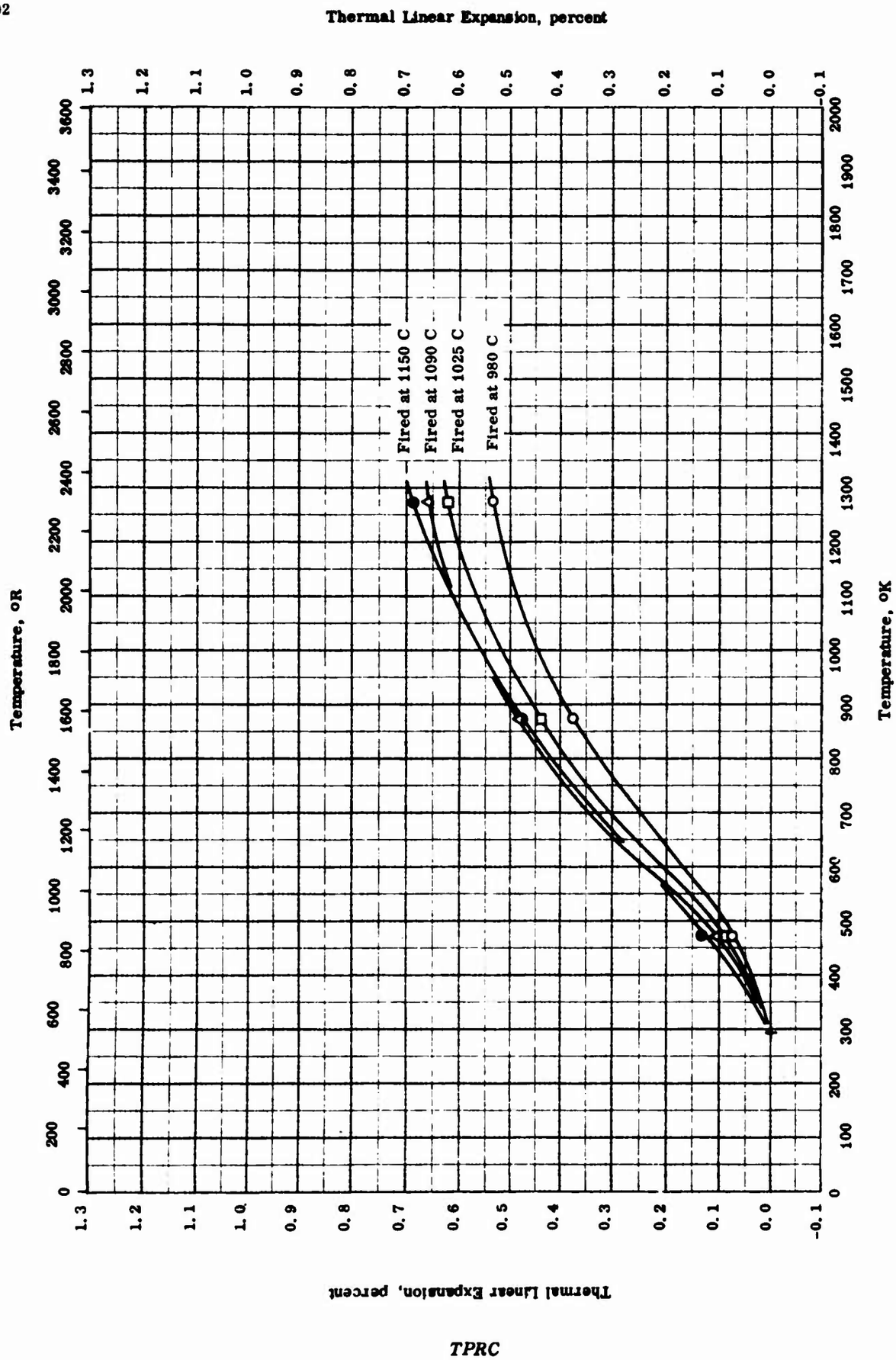
THERMAL DIFFUSIVITY -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON(IC) OXIDE

TPRC

THERMAL DIFFUSIVITY -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON(IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	21-1	773-1373		Firebrick; 68.38 SiO_2, 26.12 Al_2O_3, and 2.5 Fe_2O_3; close structure, not much clay grog, but large proportion of angular quartz grains; adherence very good, very few fissures; quartz grains very evenly graded and possible all pass an 8's lawn; faces of brick not good, very fine black cores, and appearance of many pinholes; 17.3% porosity and 2.46 true specific gravity; sample dimension 9 by 4 1/2 by 2 1/2 in.	Heat flow in lengthwise direction.

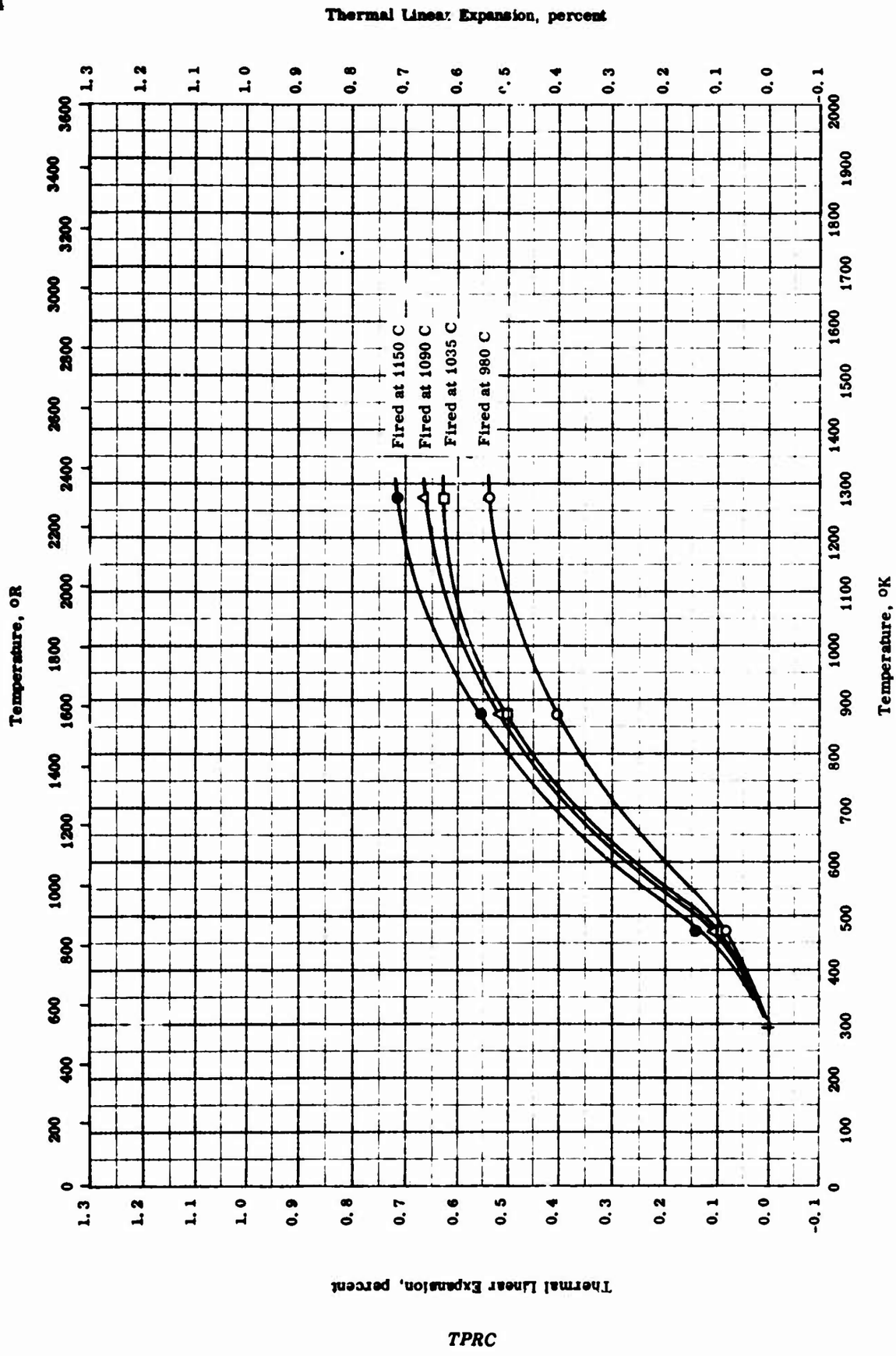


THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON (IC) OXIDE
(Effect of firing temperature for 57.18 SiO_2, 21.84 Al_2O_3, and 9.54 Fe_2O_3)

THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON (IC) OXIDE
(Effect of firing temperature for 57.18 SiO_2, 21.84 Al_2O_3, and 9.54 Fe_2O_3)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-32	293-1273		Etruria Marl; 57.18 SiO_2, 21.84 Al_2O_3, 9.54 Fe_2O_3, 1.63 K_2O, 1.26 TiO_2, 0.88 MgO, 0.16 CaO, 0.04 Na_2O, and trace of MnO. [Author's design: Sample L]	Fired at 980 C for 21 hrs (Bullers' ring reading of 1 1/2); reference temperature not given, assumed to be 20 C.
□	62-32	293-1273		Same as above.	Same as above except fired at 1035 C for 22 hrs (Bullers' ring reading of 10).
△	62-32	293-1273		Same as above.	Same as above except fired at 1090 C for 23 hrs (Bullers' ring reading of 17).
●	62-32	293-1273		Same as above; apparent porosity 11.8%.	Same as above except fired at 1150 C for 24 hrs (Bullers' ring reading of 27 1/2).

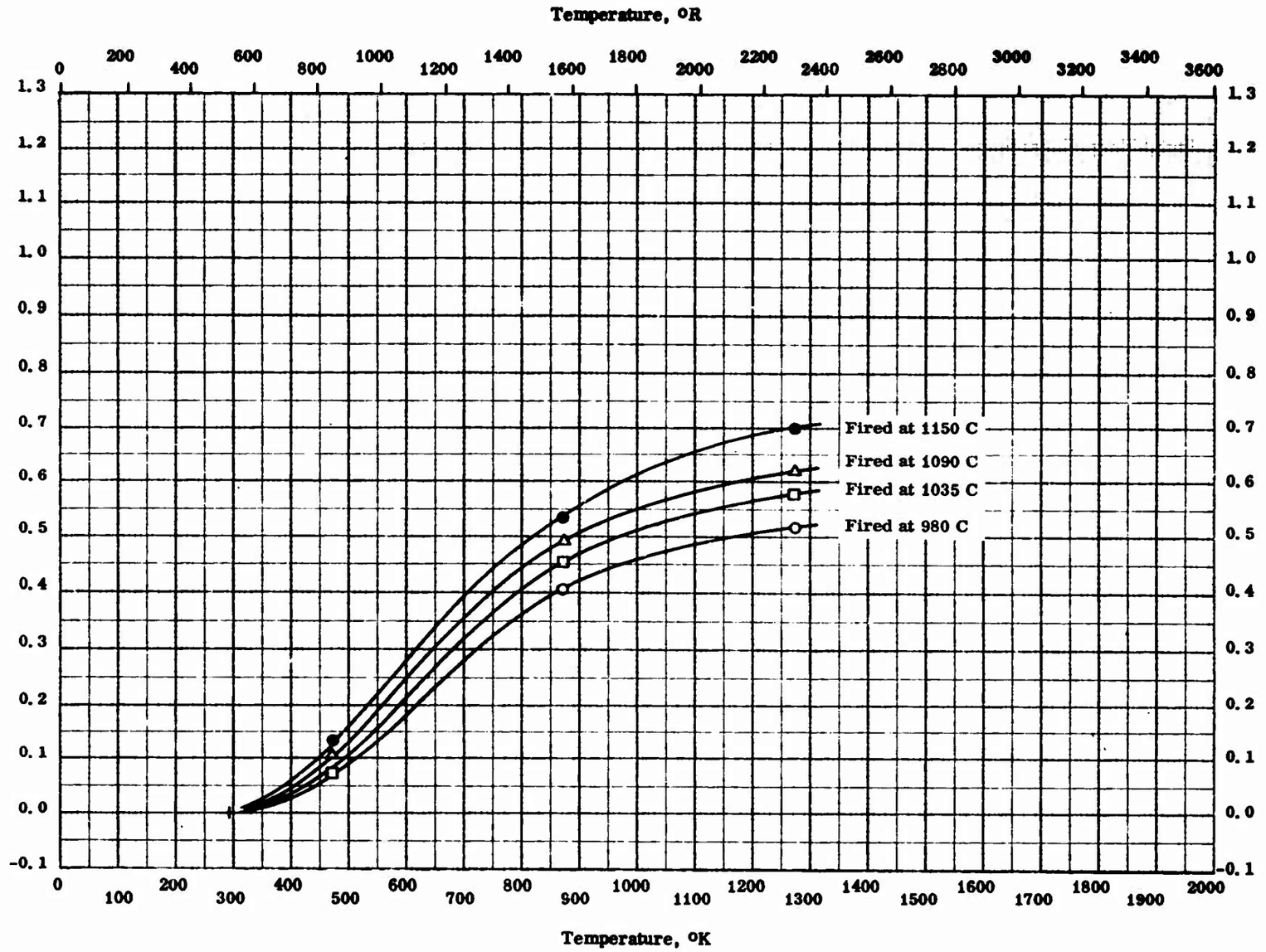


THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON(IC) OXIDE
(Effect of firing temperature for 61.53 SiO_2, 19.82 Al_2O_3 and 8.12 Fe_2O_3)

THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON(IC) OXIDE
(Effect of firing temperature for 61.53 SiO_2, 19.82 Al_2O_3 and 8.12 Fe_2O_3)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-32	293-1273		Etruria Marl; 61.53 SiO_2, 19.82 Al_2O_3, 8.12 Fe_2O_3, 1.46 TiO_2, 1.40 K_2O, 0.77 MgO, 0.09 Na_2O, 0.06 CaO, and trace of MnO. [Author's design: Sample H]	Fired at 980 C for 21 hrs (Bullers' ring reading of 1 1/2); reference temperature not given, assumed to be 20 C.
□	62-32	293-1273		Same as above.	Same as above except fired at 1035 C for 22 hrs (Bullers' ring reading of 10).
△	62-32	293-1273		Same as above.	Same as above except fired at 1090 C for 23 hrs (Bullers' ring reading of 17).
●	62-32	293-1273		Same as above; apparent porosity 21.6%.	Same as above except fired at 1150 C for 24 hrs (Bullers' ring reading of 27 1/2).

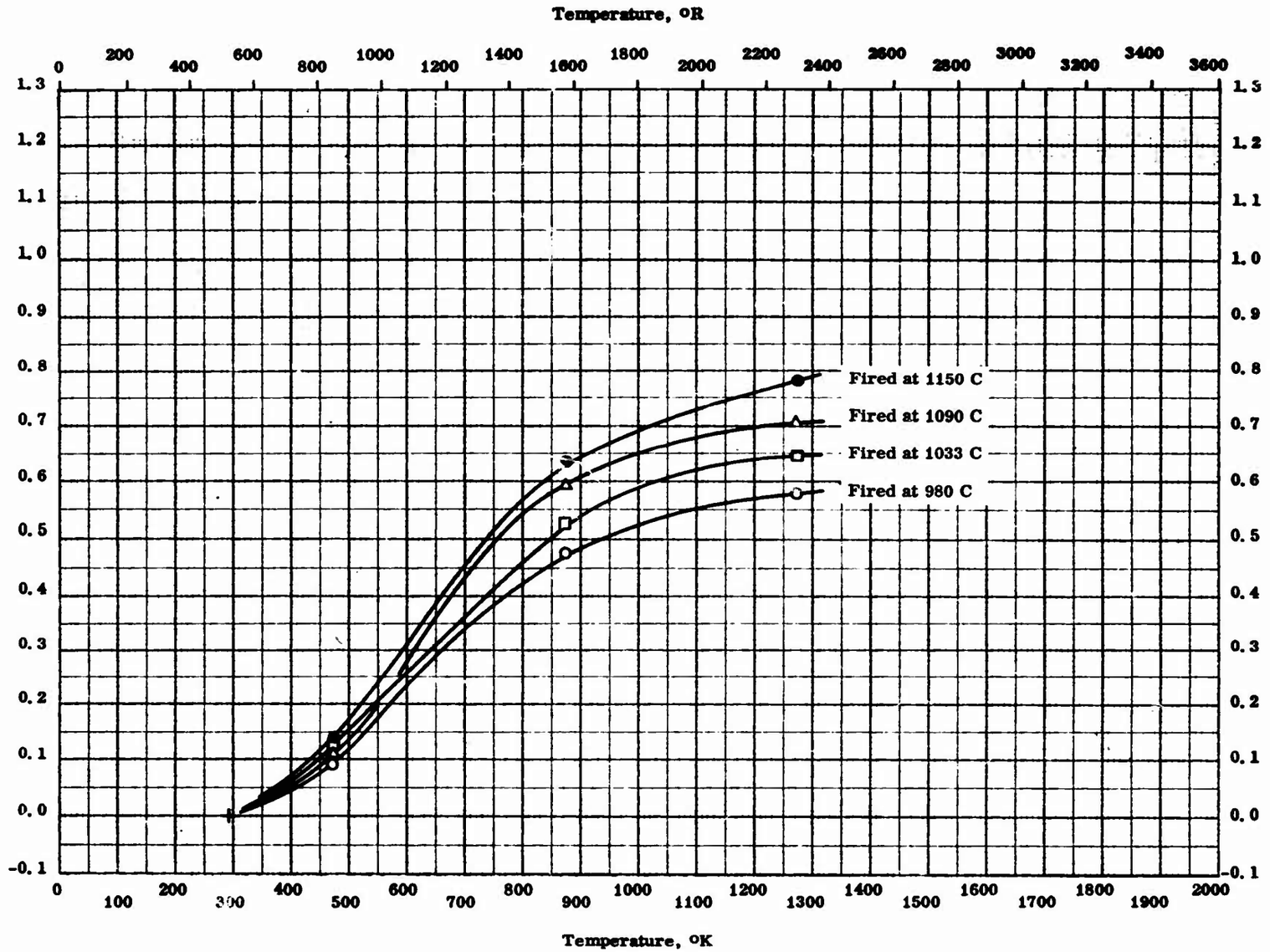


THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON (IC) OXIDE
(Effect of firing temperature for 63.30 SiO_2, 19.92 Al_2O_3, and 6.49 Fe_2O_3)

THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON(IC) OXIDE
(Effect of firing temperature for 63.30 SiO_2, 19.92 Al_2O_3, and 6.49 Fe_2O_3)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-32	293-1273		Etruia Marl; 63.30 SiO_2, 19.92 Al_2O_3, 6.49 Fe_2O_3, 1.21 TiO_2, 1.20 K_2O, 0.98 MgO, 0.12 CaO, 0.07 Na_2O, and trace of MnO. [Author's design; sample J]	Fired at 980 C for 21 hrs (Bullers' ring reading of 1 1/2; reference temperature not given, assumed to be 20 C.
□	62-32	293-1273		Same as above.	Same as above except fired at 1035 C for 22 hrs (Bullers' ring reading of 10).
△	62-32	293-1273		Same as above.	Same as above except fired at 1090 C for 23 hrs (Bullers' ring reading of 17).
●	62-32	293-1273		Same as above; apparent porosity 21.7%.	Same as above except fired at 1150 C for 24 hrs (Bullers' ring reading of 27 1/2).



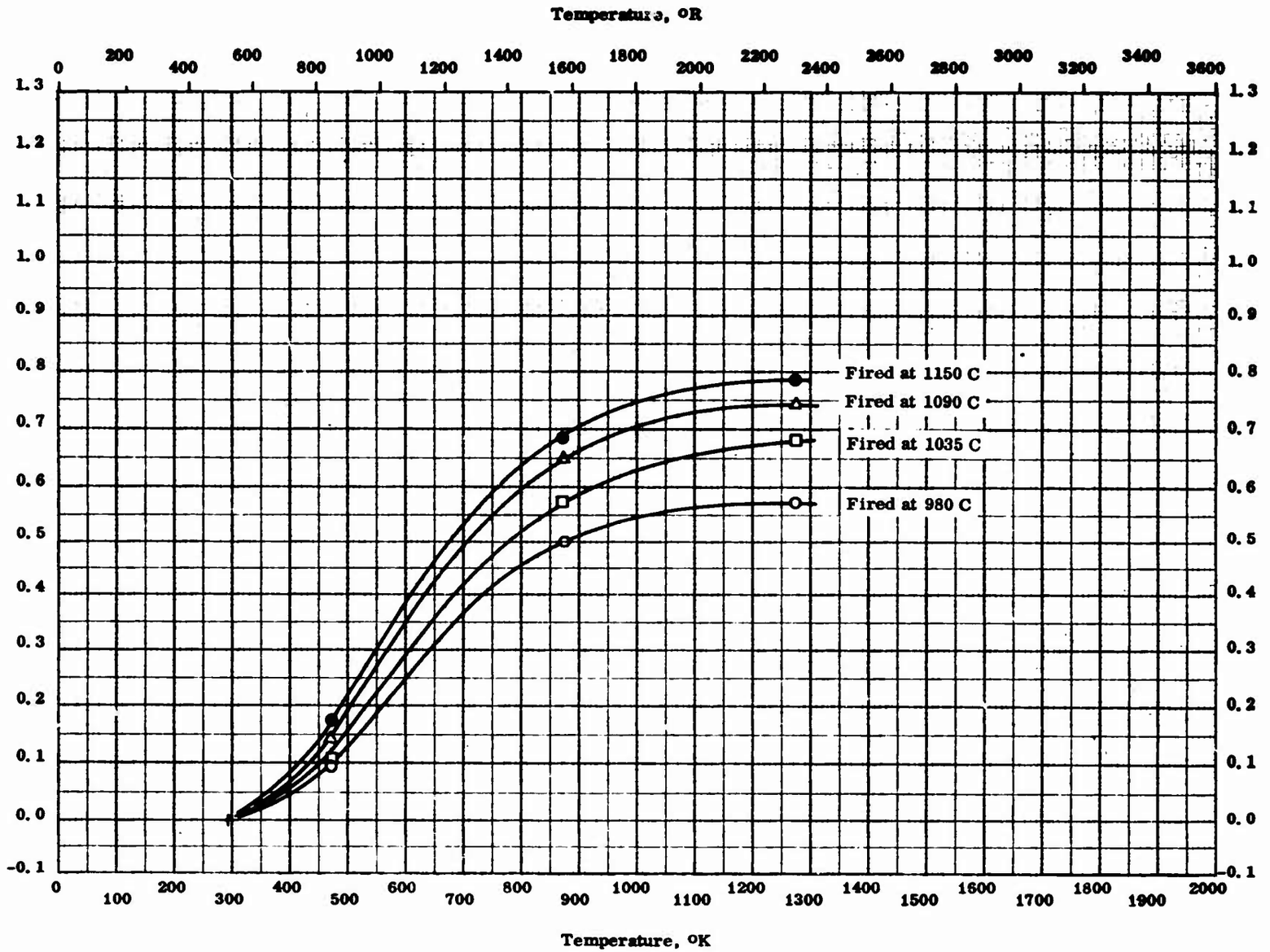
THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON (IC) OXIDE
(Effect of firing temperature for 65.49 SiO_2, 16.42 Al_2O_3, and 9.10 Fe_2O_3)

Thermal Linear Expansion, percent

THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON(IC) OXIDE
(Effect of firing temperature for 65.49 SiO_2, 16.42 Al_2O_3, and 9.10 Fe_2O_3)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-32	293-1273		Etruria Marl; 65.49 SiO_2, 16.42 Al_2O_3, 9.10 Fe_2O_3, 1.31 TiO_2, 1.17 K_2O, 0.88 MgO, 0.15 Na_2O, 0.01 CaO, and trace of MnO. [Author's design: Sample G]	Fired at 980 C for 21 hrs (Bullers' ring reading of 1 1/2); reference temperature not given, assumed to be 20 C.
□	62-32	293-1273		Same as above.	Same as above except fired at 1035 C for 22 hrs (Bullers' ring reading of 10).
△	62-32	293-1273		Same as above.	Same as above except fired at 1090 C for 23 hrs (Bullers' ring reading of 17).
●	62-32	293-1273		Same as above; apparent porosity 24.7%.	Same as above except fired at 1150 C for 24 hrs (Bullers' ring reading of 27 1/2).



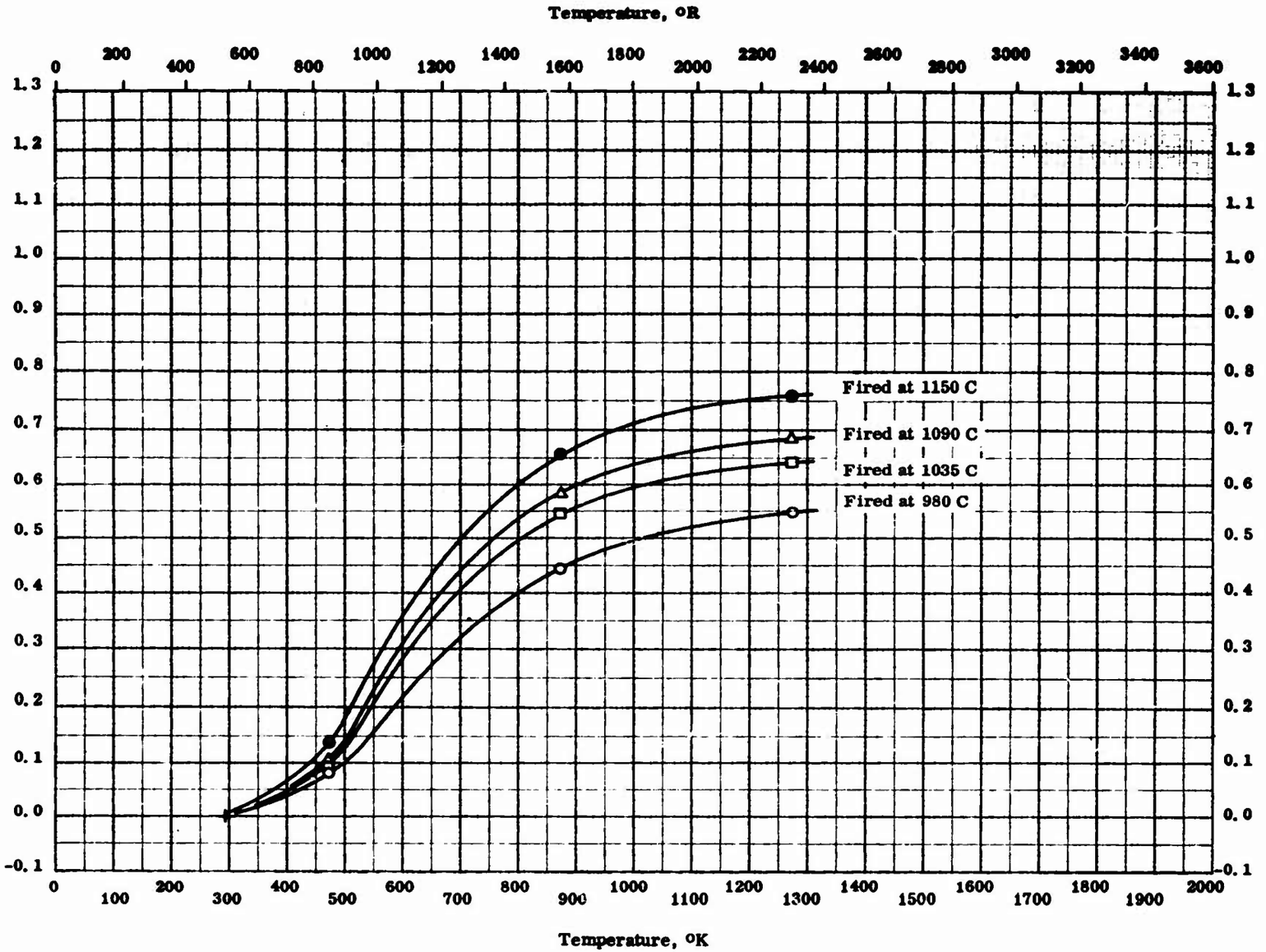
THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON (IC) OXIDE
(Effect of firing temperature for 68.57 SiO_2, 13.66 Al_2O_3, and 9.90 Fe_2O_3)

TPRC

THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON (IC) OXIDE
(Effect of firing temperature for 68.57 SiO_2, 13.66 Al_2O_3, and 9.90 Fe_2O_3)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-32	293-1273		Etruria Marl; 68.57 SiO_2, 13.66 Al_2O_3, 9.90 Fe_2O_3, 1.28 TiO_2, 0.78 K_2O, 0.56 MgO, 0.07 Na_2O, and trace of MnO and CaO. [Author's design : Sample K]	Fired at 980 C for 21 hrs (Bullers' ring reading of 1-1/2); reference temperature not given, assumed to be 20 C.
□	62-32	293-1273		Same as above.	Same as above except fired at 1035 C for 22 hrs (Bullers' ring reading of 10).
△	62-32	293-1273		Same as above.	Same as above except fired at 1090 C for 23 hrs (Bullers' ring reading of 17).
●	62-32	293-1273		Same as above; apparent porosity 26.2%.	Same as above except fired at 1150 C for 24 hrs (Bullers' ring reading of 27-1/2).

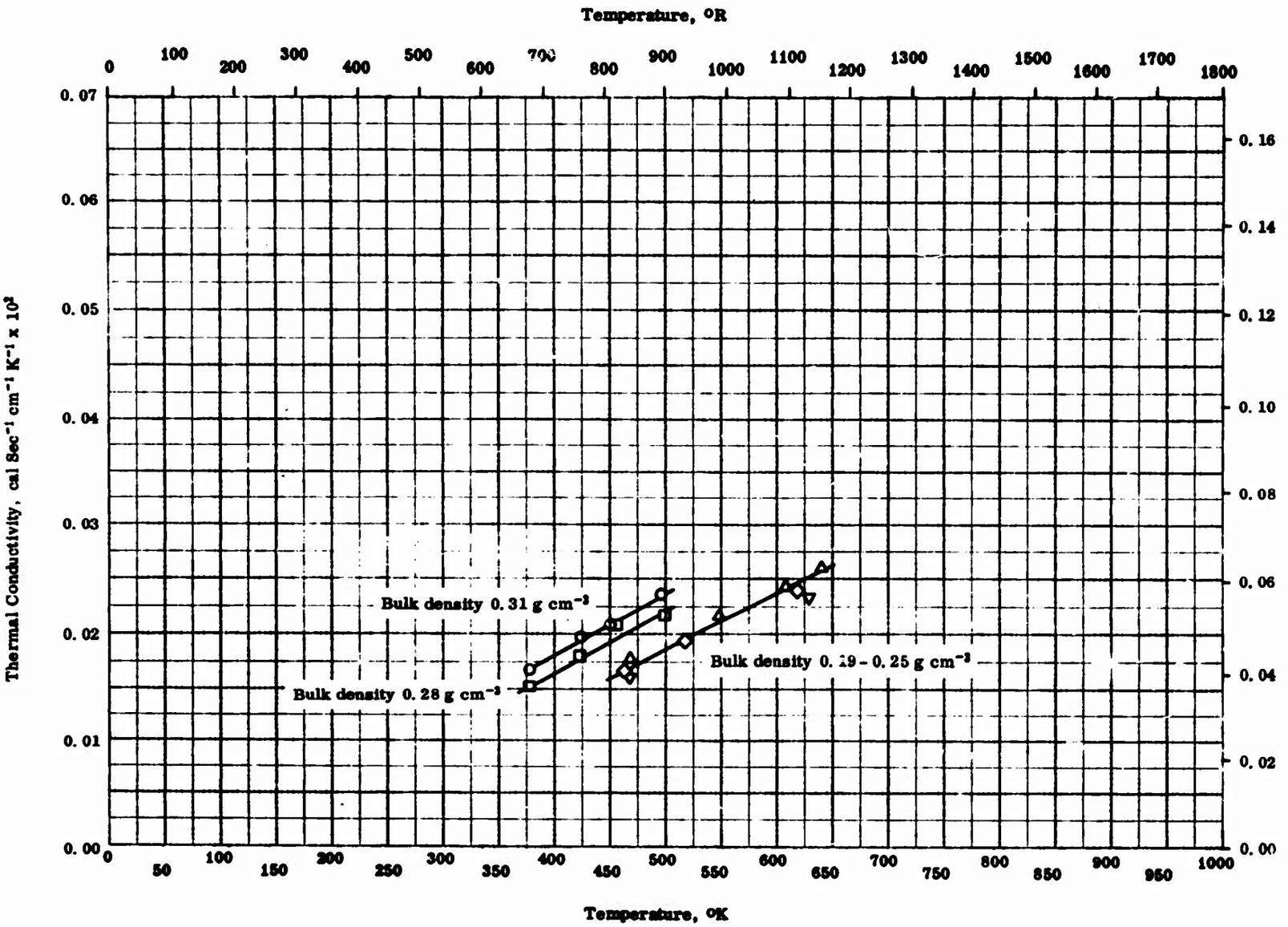


THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON (IC) OXIDE
(Effect of firing temperature for 70.32 SiO_2, 14.58 Al_2O_3, and 7.12 Fe_2O_3)

THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + ALUMINUM OXIDE + IRON (IC) OXIDE
(Effect of firing temperature for 70.32 SiO_2, 14.58 Al_2O_3, and 7.12 Fe_2O_3)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-32	293-1273		Etruria Marl; 70.32 SiO_2, 14.58 Al_2O_3, 7.12 Fe_2O_3, 1.24 TiO_2, 0.98 K_2O, 0.74 MgO, 0.08 Na_2O, 0.01 CaO, and trace of MnO. [Author's design : Sample I]	Fired at 980 C for 21 hrs (Bullers' ring reading of 1-1/2); reference temperature not given, assumed to be 20 C.
□	62-32	293-1273		Same as above.	Same as above except fired at 1035 C for 22 hrs (Bullers' ring reading of 10).
△	62-32	293-1273		Same as above.	Same as above except fired at 1090 C for 23 hrs (Bullers' ring reading of 17).
●	62-32	293-1273		Same as above; apparent porosity 26.0%.	Same as above except fired at 1150 C for 24 hrs (Bullers' ring reading of 27-1/2).



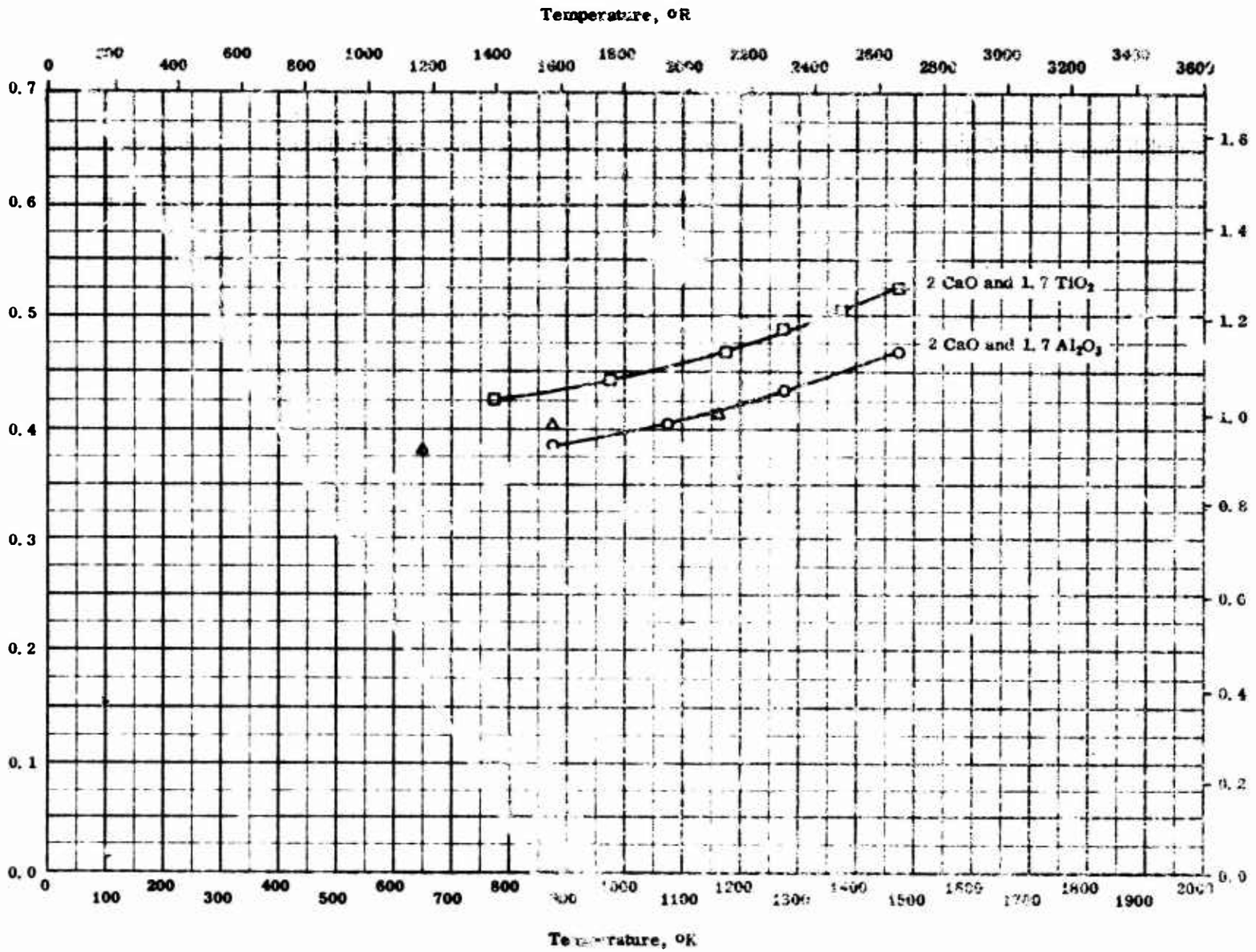
THERMAL CONDUCTIVITY -- SILICON DIOXIDE + ALUMINUM OXIDE +
+ IRON(IC) OXIDE + MAGNESIUM OXIDE + POTASSIUM MONOXIDE

TPRC

THERMAL CONDUCTIVITY -- SILICON DIOXIDE + ALUMINUM OXIDE +
+ IRON(IC) OXIDE + MAGNESIUM OXIDE + POTASSIUM MONOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	56-2	376–496		Expanded Vermiculite from Fukushima, Japan; 35.76 SiO_2, 18.7 Al_2O_3, 18.3 Fe_2O_3, 7.82 MgO, 3.61 K_2O, 1.40 CaO, 1.02 Na_2O, and 0.42 MnO; grain size by sieve analysis: 99 cumulative % by weight 100 mesh (Tylar standard scale, meshes to the inch), 97 cumulative % 60 mesh, 92 cumulative % 28 mesh, 77 cumulative % 12 mesh, 44 cumulative % 7 mesh, and 4 cumulative % 4 mesh; bulk density before pressing 0.25 g cm^{-3}.	Fired at 700 C for 5 min and pressed until volume is 20% less than the original; ignition loss 14.83% at 1200 C and 10.10% at 1000 C; density shown on figure corrected for volume loss by dividing 0.80 to bulk density before pressing.
□	56-2	378–499		Same as above except bulk density 0.225 g cm^{-3}.	Same as above except fired at 800 C for 2 min.
△	56-2	468–640		Same as above except bulk density 0.200 g cm^{-3}.	Same as above except fired at 900 C for 1 min.
◇	56-2	463–618		Same as above except bulk density 0.175 g cm^{-3}.	Same as above except fired at 1000 C for 1/4 min.
▽	56-2	468–628		Same as above except bulk density 0.15 g cm^{-3}.	Same as above except fired at 1100 C for 1/12 min.



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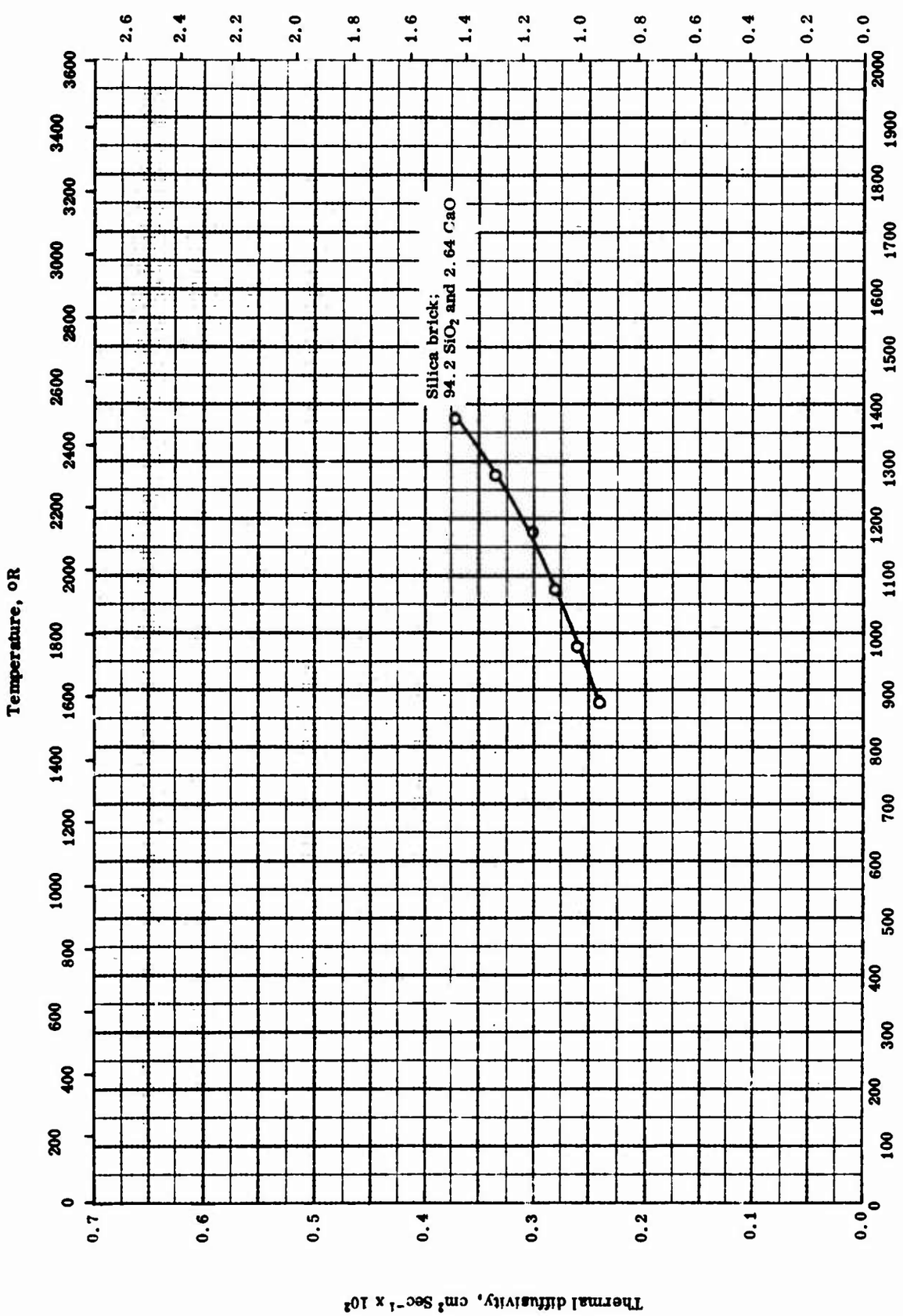
Thermal Conductivity, cal Sec^{-1} cm^{-1} K^{-1} x 10^2

Thermal Conductivity, Btu hr^{-1} ft^{-1} R^{-1}

THERMAL CONDUCTIVITY -- SI[illegible] OXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	57-2	873-1473	± 5.0	95.33 SiO_2, 2.07 CaO, 1.71 Al_2O_3, 0.53 Fe_2O_3, 0.25 Na_2O, 0.13 K_2O, 0.12 TiO_2, and 0.12% loss on ignition; bulk density 107 lb ft^{-3} (cf. theor. density 146); apparent porosity 26.4%.	
□	57-2	773-1473	± 5.0	94.20 SiO_2, 2.01 CaO, 1.72 TiO_2, 0.76 Fe_2O_3, 0.29 Al_2O_3, 0.22 MnO, trace of MgO, no K_2O, Na_2O or loss on ignition; bulk density 119 lb ft^{-3} (cf. theor. density 146); apparent porosity 18.7%.	Made from South African silcrete rock.
△	57-6	650-1161		Coke oven silica brick.	



THERMAL DIFFUSIVITY -- SILICON DIOXIDE + CALCIUM OXIDE

THERMAL DIFFUSIVITY -- SILICON DIOXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	21-1	873-1373		Silica brick; 94.02 SiO_2, 2.64 CaO, and 1.78 Al_2O_3; exceptionally fine-grained, close and uniform texture, and major portion of material of sand size; fragments of rock of appreciable size scarce and those seen vary from round to sub-angular; friable; 38.2% porosity with pores seemed to be even in size and 2.44 true specific gravity; specimen dimension 9 by 4 1/2 by 2 1/2 in.	Heat flow in lengthwise direction

PROPERTIES OF SILICON DIOXIDE + IRON (IC) OXIDE

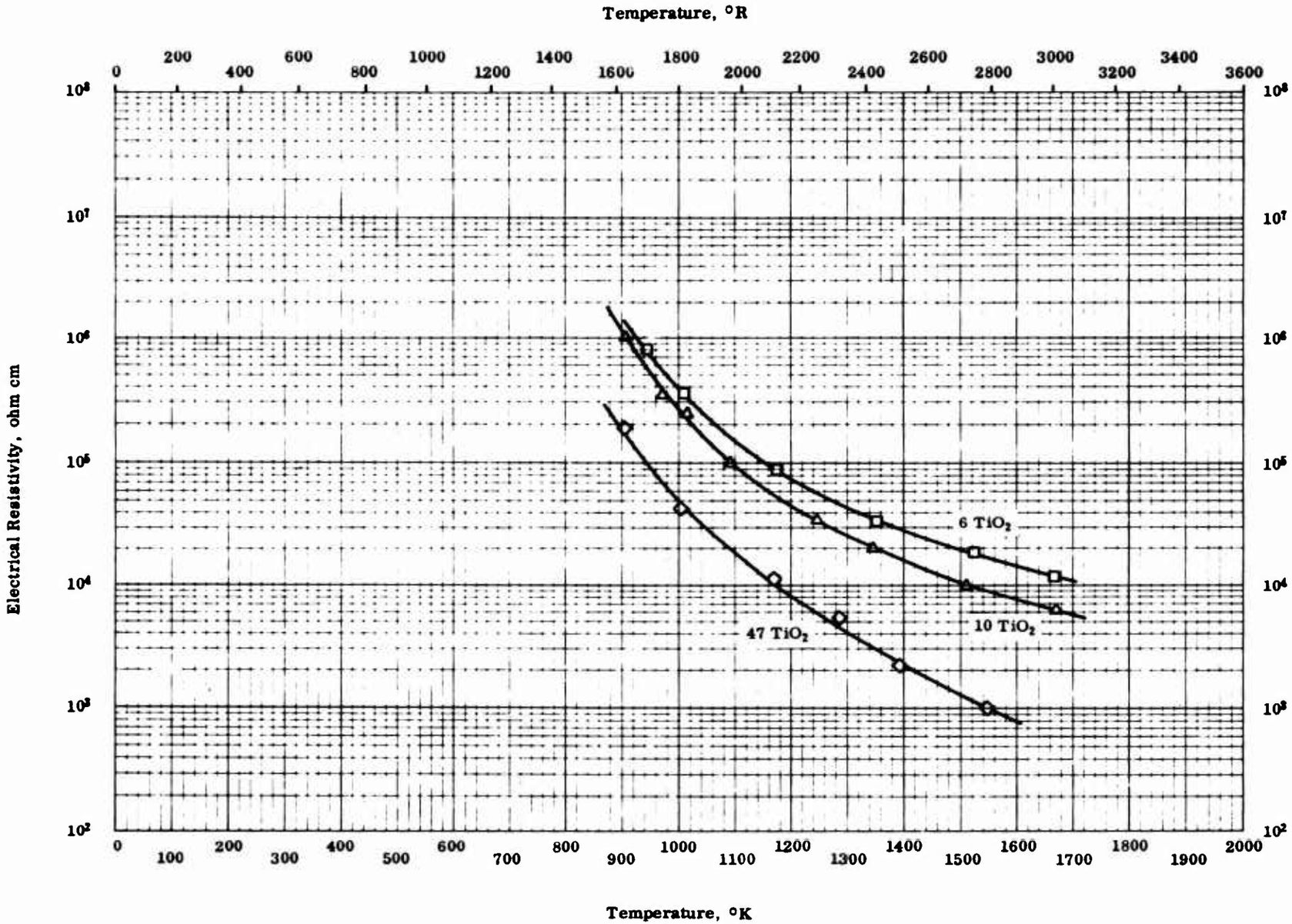
REPORTED VALUES

Density		g cm^{-3}	lb ft^{-3}
▽	2.17 Fe_2O_3	2.628	164.0
○	2.17 Fe_2O_3	2.321	144.9

PROPERTIES OF SILICON DIOXIDE + IRON (IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▽	55-28	298		Silica rock; 97.23 SiO_2, 2.17 Fe_2O_3, 0.20 Al_2O_3, 0.18 alkalis, 0.09 CaO, 0.03 MgO.	Fired 3 hrs. at 1311 C in air.
○	55-28	298		Same as above.	Fired 4 hrs. at 1550 C in air.



TPRC

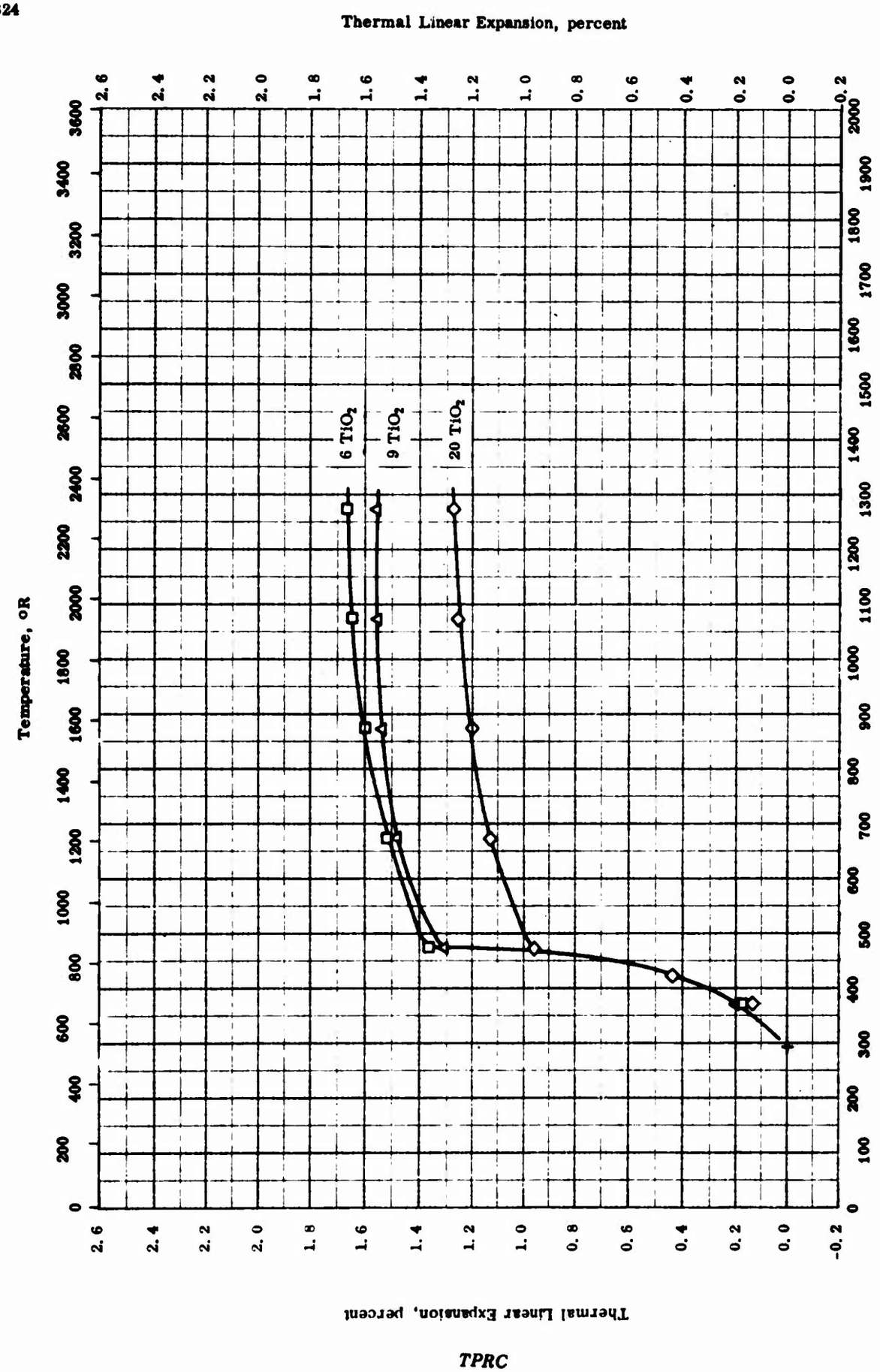
Electrical Resistivity, ohm cm

ELECTRICAL RESISTIVITY -- SILICON DIOXIDE + TITANIUM DIOXIDE

ELECTRICAL RESISTIVITY -- SILICON DIOXIDE + TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	53-17	943-1723		94 SiO_2 and 6 TiO_2.	Fired 24 hrs at 1450 C.
△	53-17	902-1673		90 SiO_2 and 10 TiO_2.	Same as above.
◇	53-17	903-1543		53 SiO_2 and 47 TiO_2.	Same as above.



THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + TITANIUM DIOXIDE

THERMAL LINEAR EXPANSION -- SILICON DIOXIDE + TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	51-25	293-1273		94 SiO_2 and 6 TiO_2.	Heated 2 hrs at 1540 C and 8 hrs at 1500 C.
△	51-25	293-1273		91 SiO_2 and 9 TiO_2.	Same as above.
◇	51-25	293-1273		80 SiO_2 and 20 TiO_2.	Same as above.

PROPERTIES OF SILICON DIOXIDE + ΣX_i

REPORTED VALUES

Density		g cm^{-3}	lb ft^{-3}
○	2.87 Al_2O_3 + Fe_2O_3	2.658	165.9
□	2.87 Al_2O_3 + Fe_2O_3	2.339	146.0
△	2.87 Al_2O_3 + Fe_2O_3	2.635	164.5
◇	2.87 Al_2O_3 + Fe_2O_3	2.341	146.1

PROPERTIES OF SILICON DIOXIDE + ΣX_i

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	55-28	298		Silica rock; 95.68 SiO_2, 2.87 Al_2O_3 + Fe_2O_3, 0.81 CaO, and 0.24 MgO.	Fired 2 hrs at 1203 C in air; density by pycnometer.
□	55-28	298		Same as above.	Fired at 1540 C for 4 hrs in air; same as above.
△	55-28	298		Same as above.	Fired at 1201 C for 2 hrs in reducing atm. of 0.8 atm. of Co and 0.2 atm. of N_2; same as above.
◇	55-28	298		Same as above.	Fired 4 hrs at 1600 C in air; same as above.

PROPERTIES OF STRONTIUM OXIDE + TITANIUM DIOXIDE

REPORTED VALUES

Melting Point	K	R
○ 72.1 SrO.	2073 ±20	3732 ± 36
□ 73.6 - 83.8 SrO.	2013	3624

PROPERTIES OF STRONTIUM OXIDE + TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	55-27	2053-2093		72.1 SrO and 27.9 TiO_2.	Presintered at 1100 C and sintered at 1350 - 1500 C; M.P. by visual observation.
□	55-27	2017		Eutectic of 2 SrO - TiO_2 and SrO; 73.6 - 83.8 SrO.	Same as above.

TPRC

PROPERTIES OF THORIUM DIOXIDE + ALUMINUM OXIDE

REPORTED VALUES

Melting Point	K	R
O 27.9 Al_2O_3.	2188 ±5	3938 ± 8

PROPERTIES OF THORIUM DIOXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-26	2183-2193	± 2	72.1 ThO_2 and 27.9 Al_2O_3.	Average of 3 - 5 tests by visual observation.

PROPERTIES OF THORIUM DIOXIDE + ALUMINUM OXIDE + BERYLLIUM OXIDE

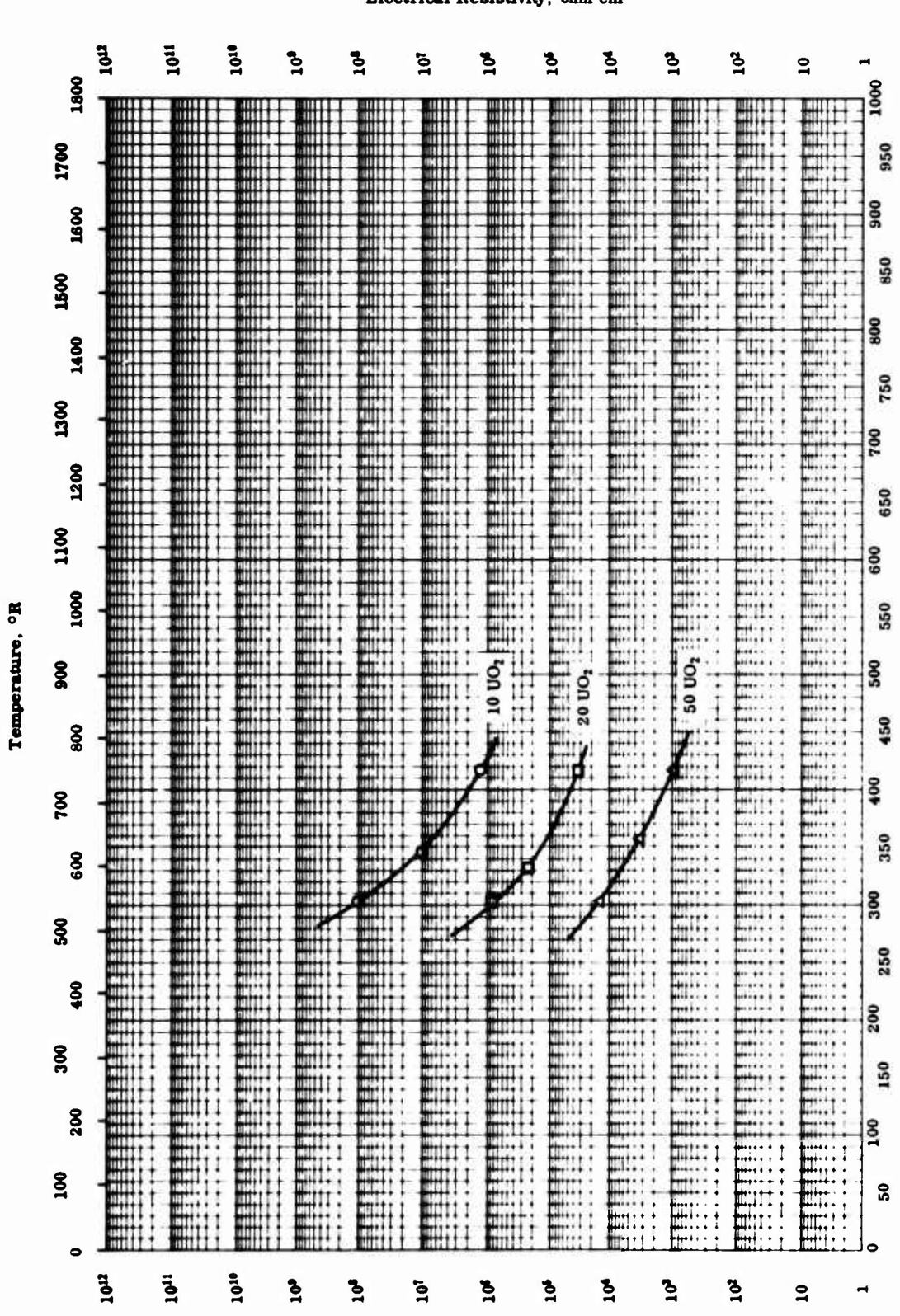
REPORTED VALUES

Melting Point		K	R
O	15.6 Al_2O_3 and 3.8 BeO	2078 ±5	3741 ± 9

PROPERTIES OF THORIUM DIOXIDE + ALUMINUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-26	2073-2083	± 2	80.6 ThO_2, 15.6 Al_2O_3, and 3.8 BeO.	Average of 3 - 5 tests by visual observation.

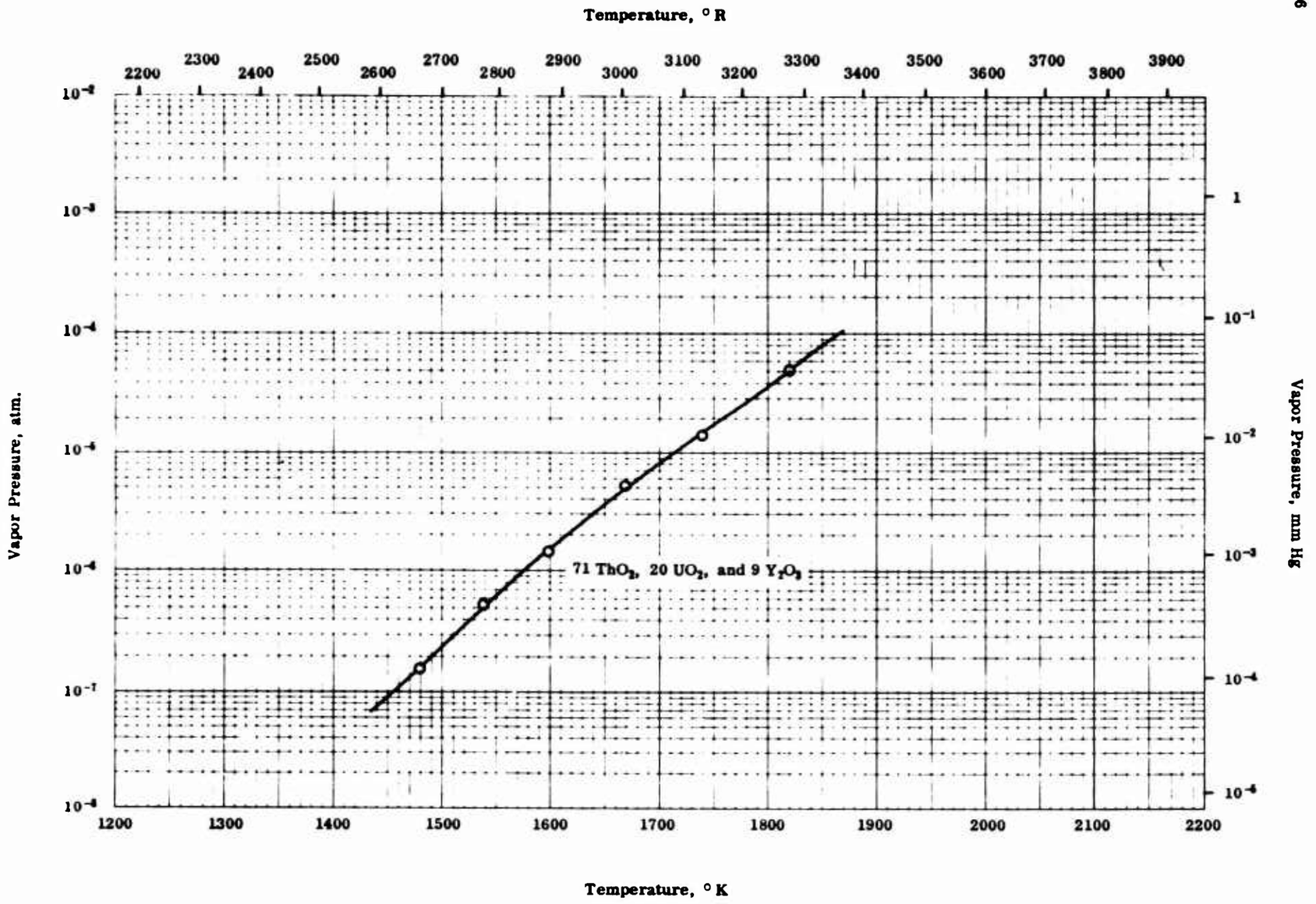


ELECTRICAL RESISTIVITY -- THORIUM DIOXIDE + URANIUM DIOXIDE

ELECTRICAL RESISTIVITY -- THORIUM DIOXIDE + URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-24	303-417		90 ThO_2 and 10 UO_2; prepared from elements with 0.01> transition and rare earth metals.	Mixed, pressed, and fired 8 hrs at 1750 C in H_2.
□	54-24	303-417		80 ThO_2 and 20 UO_2; same as above.	Same as above.
△	54-24	303-417		50 ThO_2 and 50 UO_2; same as above.	Same as above.



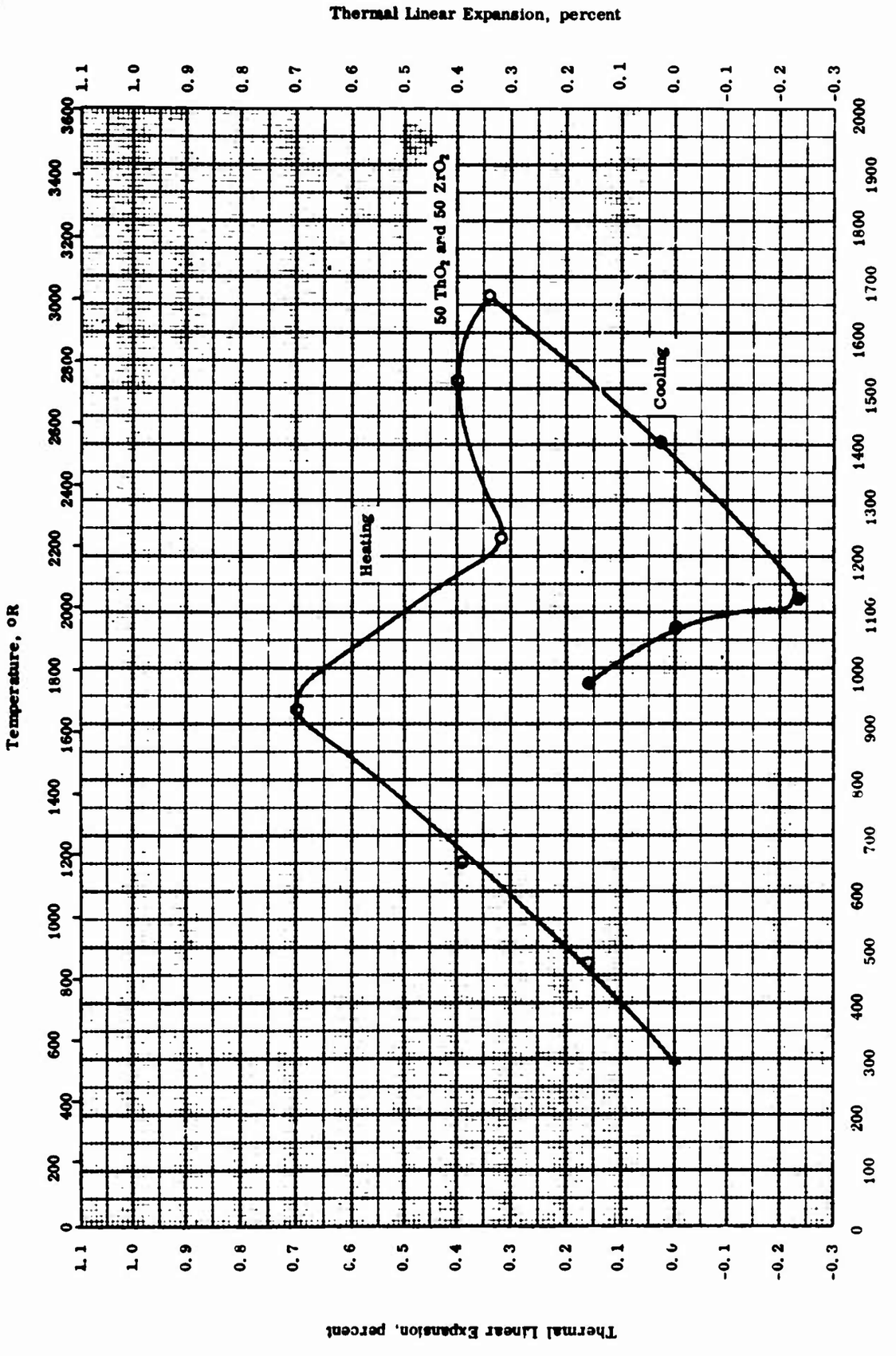
TPRC

VAPOR PRESSURE -- THORIUM DIOXIDE + URANIUM DIOXIDE + YTTRIUM OXIDE

VAPOR PRESSURE -- THORIUM DIOXIDE + URANIUM DIOXIDE + YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	64-4	1480-1820		70.80 ThO_2, 20.0 UO_2, and 9.20 Y_2O_3.	Corresponding to UO_2: $4ThO_2$: 0.55Y_2O_3; mixed and reacted for 1 hr in air at 1850 C using high-purity BeO refractories.

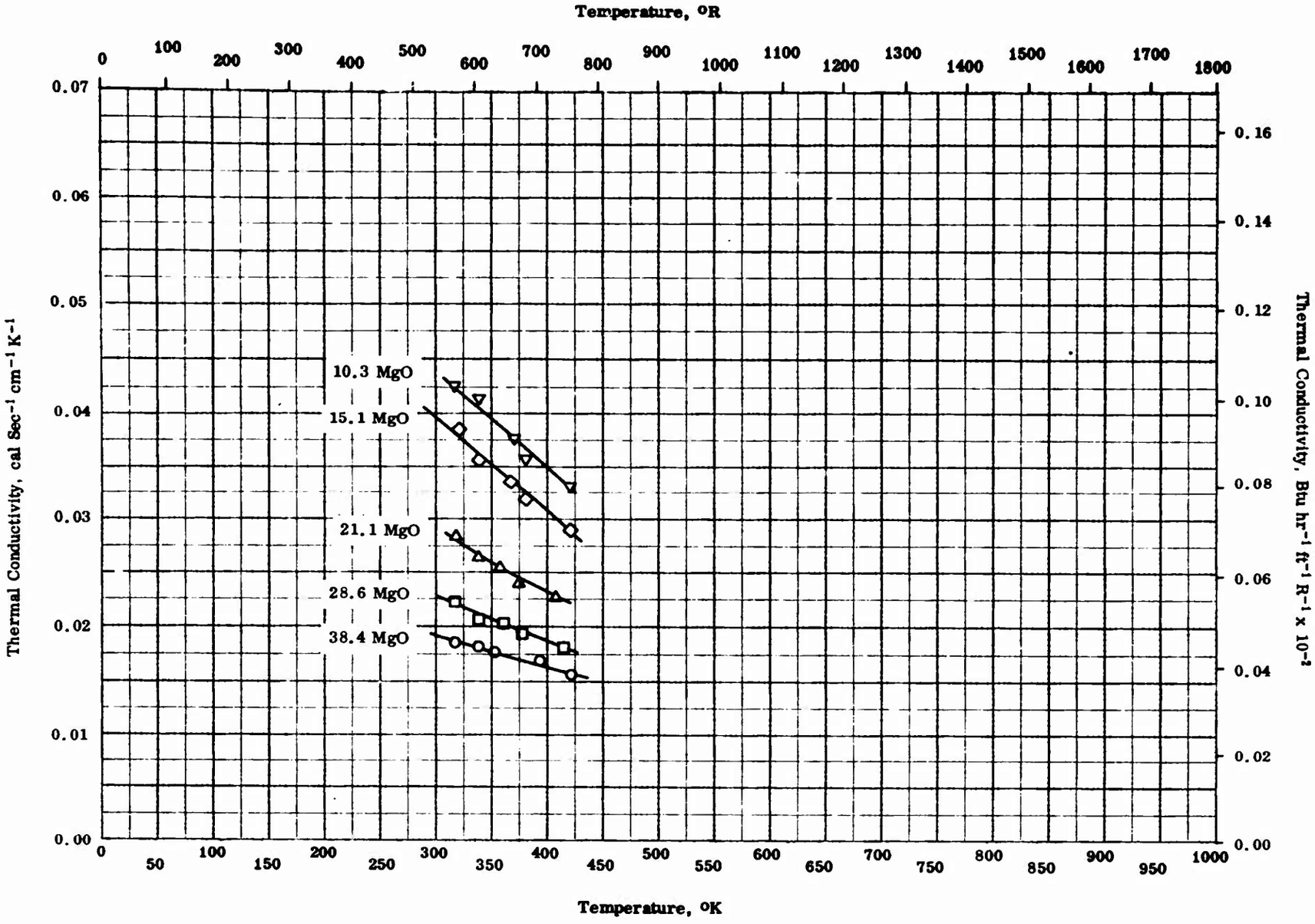


THERMAL LINEAR EXPANSION -- THORIUM DIOXIDE + ZIRCONIUM DIOXIDE

THERMAL LINEAR EXPANSION -- THORIUM DIOXIDE + ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-41	473-1663		50 ZrO_2 and 50 ThO_2; ZrO_2 analysis: 97.8 ZrO_2, 0.57 SiO_2, 0.40 H_2O, 0.23 TiO_2, 0.16 Fe_2O_3, 1.61 ignition loss, and trace of MgO and CaO.	Component dry mixed in agate mortar, 5 dextrolyne added as binder, pressed at 1000 Kg cm^{-2}, fired to 1700 C in 5-1/2 hrs, soaked 1 hr, and cooled overnight; heated to 1000 C at 10 C min^{-1} and 1000 - 1400 C at 7 C min^{-1}; cooled to 800 C at 10 C min^{-1}, then to room temperature naturally.
●	57-41	973-1663		Same as above.	Cooling cycle for above sample.

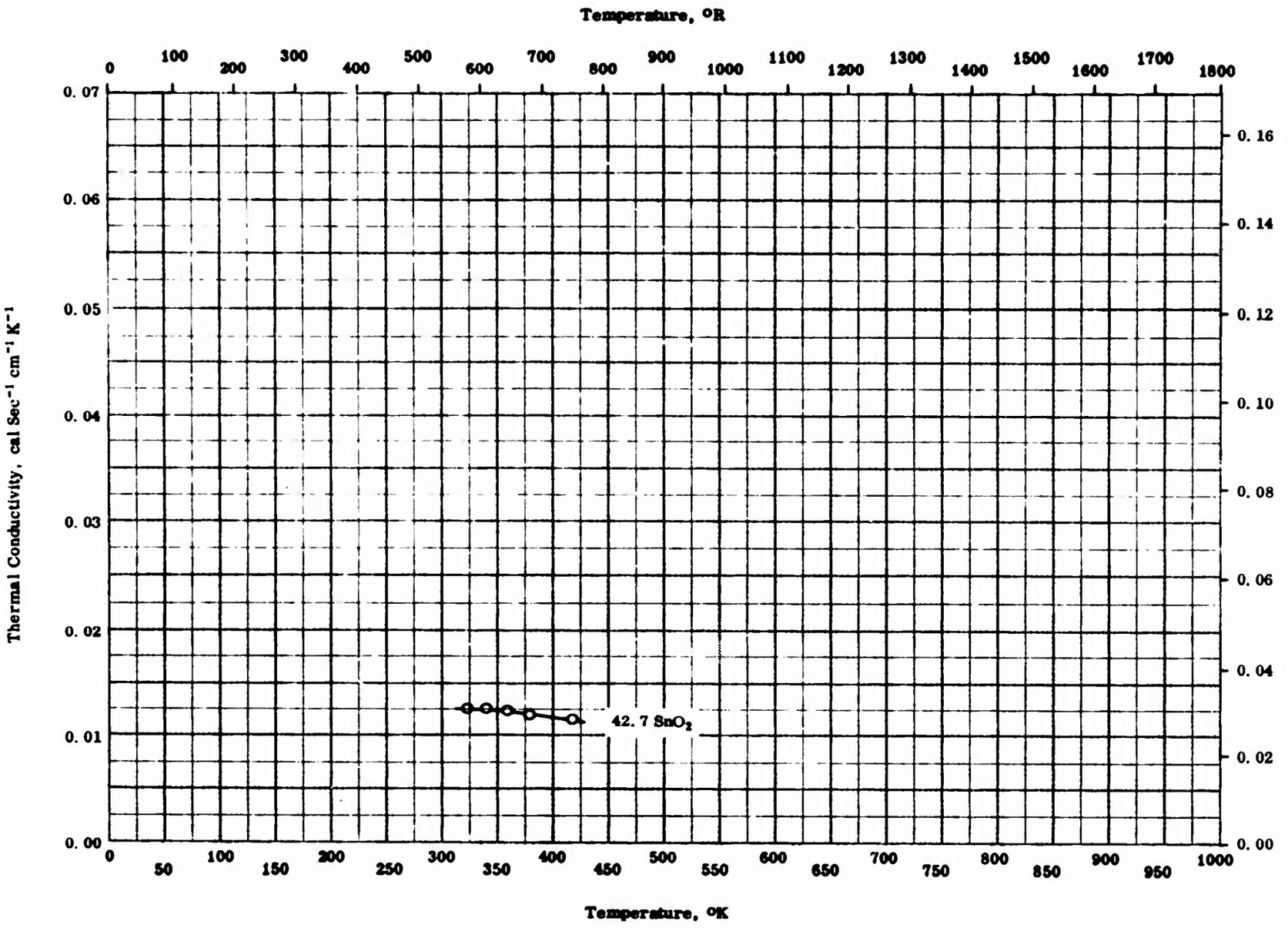


THERMAL CONDUCTIVITY -- TIN (IC) OXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- TIN (IC) OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-5	318-422		61.6 SnO_2 and 38.4 MgO; 0.12% water absorption; density 266 lb ft^{-3}.	Corresponding to 3 SnO_2 : 7 MgO; fired 1.5 hr. at 2750 F.
□	53-5	317-415		71.4 SnO_2 and 28.6 MgO; 0.098% water absorption; density 300 lb ft^{-3}.	Corresponding to 2 SnO_2 : 3 MgO; same as above.
△	53-5	319-408		78.9 SnO_2 and 21.1 MgO; 0.19% water absorption; density 324 lb ft^{-3}.	Corresponding to SnO_2: MgO; same as above.
◇	53-5	321-421		84.9 SnO_2 and 15.1 MgO; 0.46% water absorption; density 340 lb ft^{-3}.	Corresponding to 3 SnO_2 : 2 MgO; same as above.
▽	53-5	316-421		89.7 SnO_2 and 10.3 MgO; 0.70% water absorption; density 346 lb ft^{-3}.	Corresponding to 7 SnO_2 : 3 MgO; same as above.

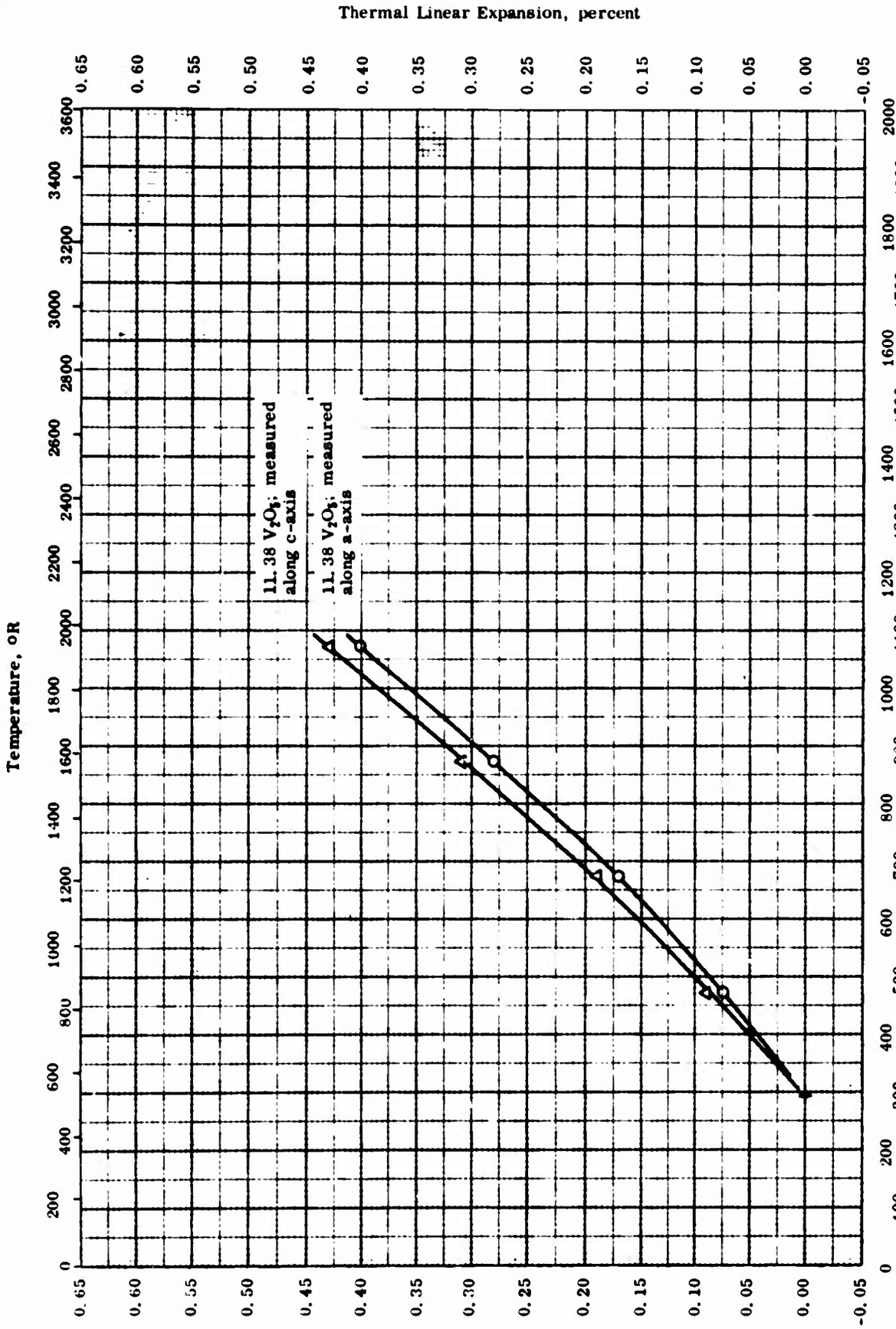


THERMAL CONDUCTIVITY -- TIN (IC) OXIDE + MAGNESIUM OXIDE + ZINC OXIDE

THERMAL CONDUCTIVITY -- TIN (IC) OXIDE + MAGNESIUM OXIDE + ZINC OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	53-6	323-417		42.7 SnO_2, 34.2 MgO, and 23.1 ZnO; density 4.34 g cm^{-3} and water absorption 0.362%.	Corresponding to 3 MgO: SnO_2; ZnO; calcined milled and dried pure oxides at 2000 F, dry-pressed at 15,000 psi, and fired at 2650 F and heat-soaked for 1 1/2 hrs.

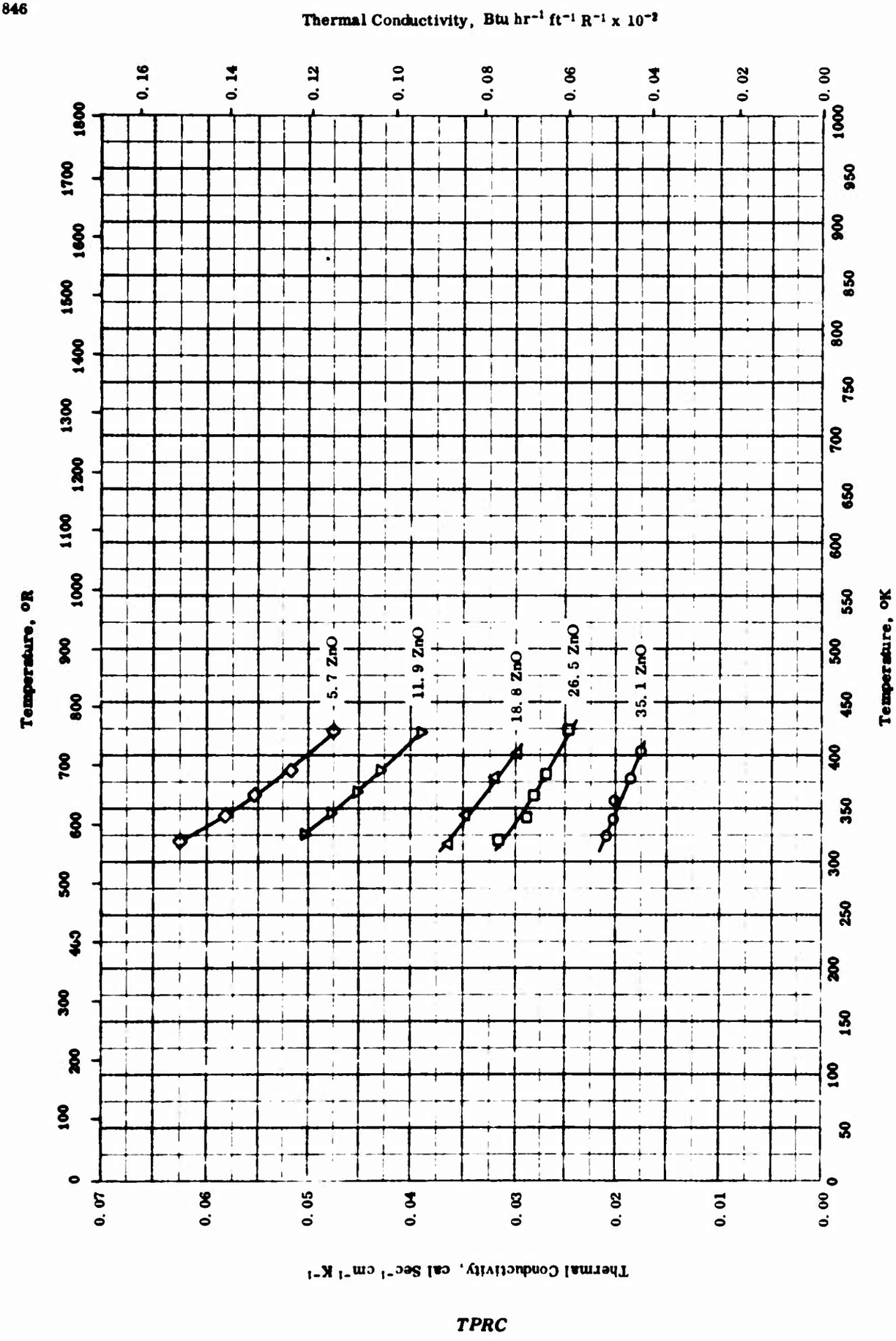


THERMAL LINEAR EXPANSION -- TIN (IC) OXIDE + VANADIUM PENTOXIDE

THERMAL LINEAR EXPANSION -- TIN (IC) OXIDE + VANADIUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	62-36	296-1073		88.17 SnO_2 and 11.83 V_2O_5.	SnO_2 and V_2O_5 ball milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15 binder (40 g Carbowax 20 M, 20 cc of 2 Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disk about 1/4 in. thick, fired to 1000 C for 16 hrs, cooled to room temperature in less than 30 min, and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
Δ	62-36	296-1073		Same as above.	Same as above except measured along c-axis.

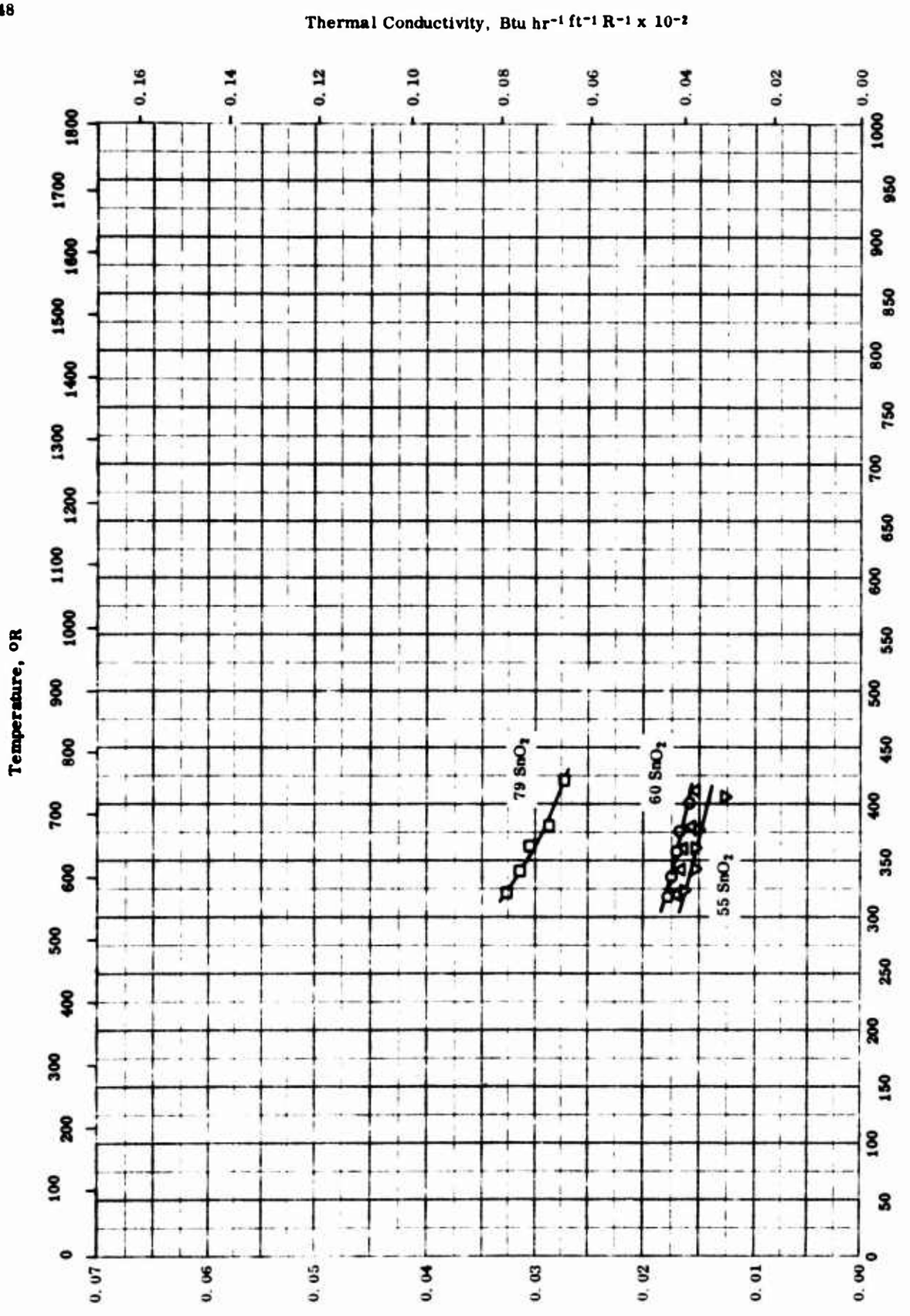


THERMAL CONDUCTIVITY -- TIN (IC) OXIDE + ZINC OXIDE

THERMAL CONDUCTIVITY -- TIN (IC) OXIDE + ZINC OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-6	324-403		64.9 SnO_2 and 35.1 ZnO; density 6.02 g cm^{-3} and water absorption 0.224%.	Corresponding to SnO_2: ZnO; prepared by calcining milled mixture of pure oxides and dry pressing at 15,000 psi; fired at 2500 F and heat-soaked for 1 hr.
□	53-6	321-424		73.5 SnO_2 and 26.5 ZnO; density 6.24 g cm^{-3} and water absorption 0.201%.	Corresponding to 3 SnO_2: 2 ZnO; same as above except fired at 2600 F and heat-soaked for 2 hrs.
△	53-6	317-402		81.2 SnO_2 and 18.8 ZnO; density 6.16 g cm^{-3} and water absorption 0.303%.	Corresponding to 7 SnO_2: 3 ZnO; same as above except heat-soaked for 1 hr after fired at 2600 F.
▽	53-6	326-421	8	88.1 SnO_2 and 11.9 ZnO; density 6.25 g cm^{-3}.	Corresponding to 4 SnO_2: ZnO; same as above except fired at 2650 F and heat-soaked for 2 hrs.
◇	53-6	319-422		94.3 SnO_2 and 5.7 ZnO; density 6.32 g cm^{-3} and water absorption 0.009%.	Corresponding to 9 SnO_2: ZnO; same as above except heat-soaked for 1 hr after fired at 2650 F.

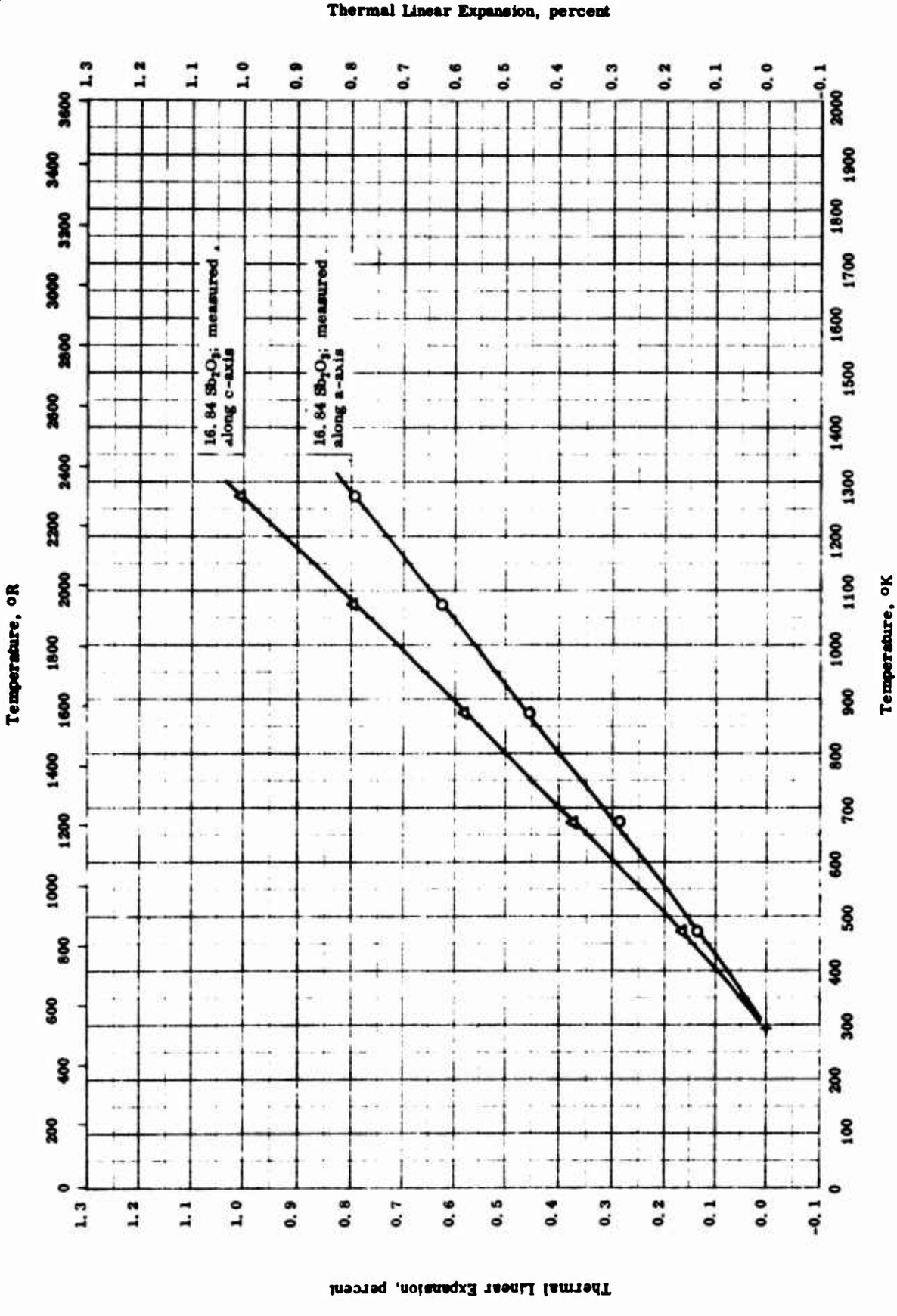


THERMAL CONDUCTIVITY -- TIN (IC) OXIDE + ZINC OXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- TIN (IC) OXIDE + ZINC OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	53-6	321-420		78.9 SnO_2, 14.2 ZnO, and 6.9 MgO; density 5.51 g cm^{-3} and water absorption 0.171%.	Corresponding to MgO : $3SnO_2$: ZnO; calcined milled and dried pure oxides at 2000 F, dry-pressed at 15,000 psi, and fired at 2550 F and heat-soaked for 1 1/2 hrs.
○	53-6	317-401		59.7 SnO_2, 32.3 ZnO, and 8.0 MgO; density 5.00 g cm^{-3} and water absorption 0.014%.	Corresponding to MgO : $2SnO_2$: 2ZnO; same as above except fired at 2600 F.
△	53-6	319-412		65.0 SnO_2, 17.6 ZnO, and 17.4 MgO; density 4.85 g cm^{-3} and water absorption 0.097%.	Corresponding to 2 MgO : $2SnO_2$: ZnO; same as above except fired at 2550 F.
▽	53-6	322-405		55.3 SnO_2, 29.9 ZnO, and 14.8 MgO; density 4.50 g cm^{-3} and water absorption 0.058%.	Corresponding to MgO : SnO_2 : ZnO; same as above except fired at 2700 F.



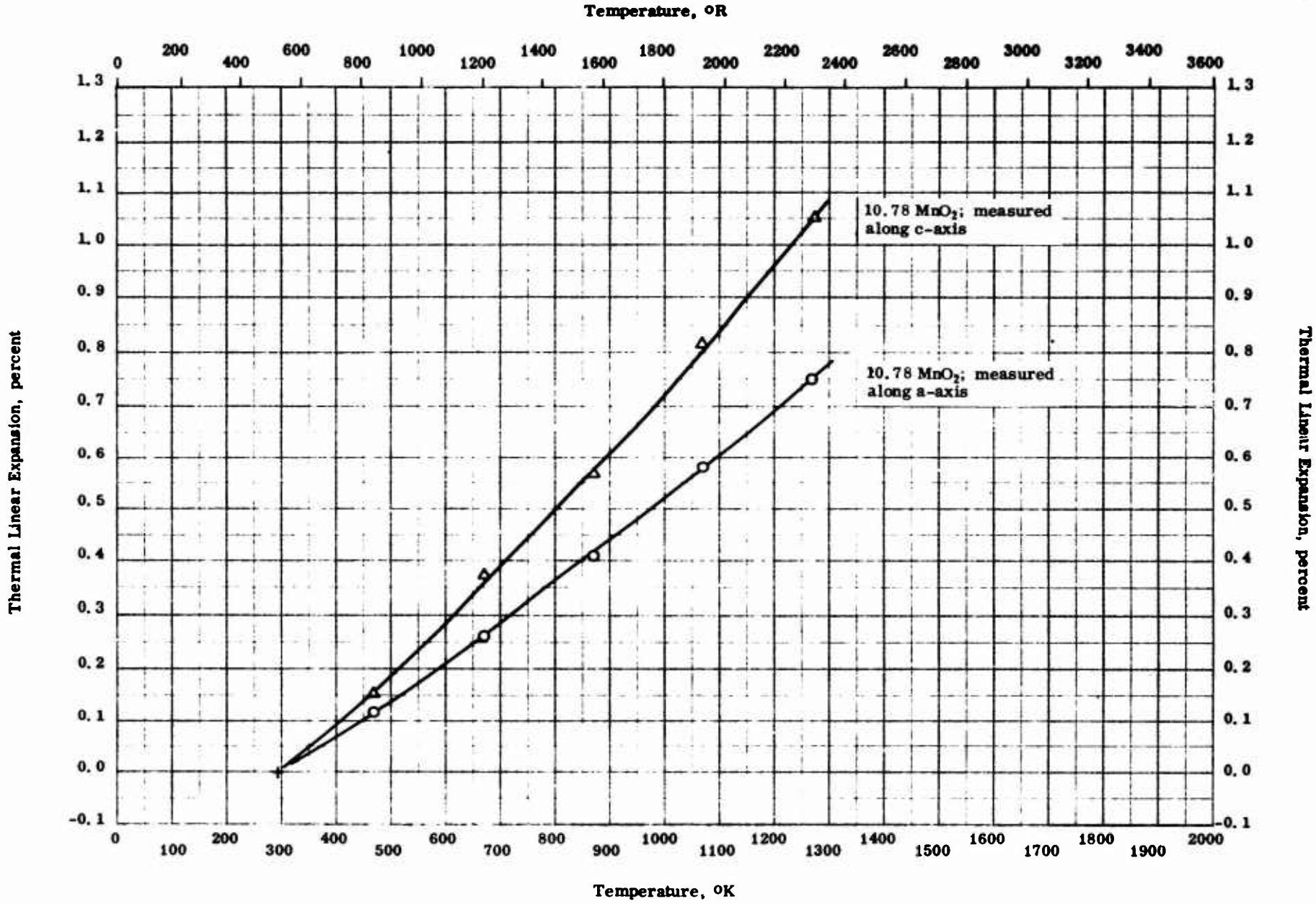
THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + ANTIMONY TRIOXIDE

THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + ANTIMONY TRIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	60-36	300-1273		83.16 TiO_2 and 16.84 Sb_2O_3; prepared from reagent grade Sb_2O_3 and Titanium Pigment Corporation's Titanox TG with 0.01> CaO, 0.1> WO_3, 0.008>Nb, 0.007> Sb_2O_3, 0.04> SiO_2, 0.006 Fe_2O_3, 0.001 V, 0.00005 Mn, 0.0005 Cu, 0.0004 Cr, and 0.001 - 0.002 Pb.	100 g TiO_2 and 20.25 g Sb_2O_3 ball-milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15 binder (40 g Carbowax 20 M, 20 cc of 2 Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired to 1200 C for 18 hrs, cooled to room temperature in less than 30 min, and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
Δ	60-36	300-1273		Same as above.	Same as above except measured along c-axis.

TPRC

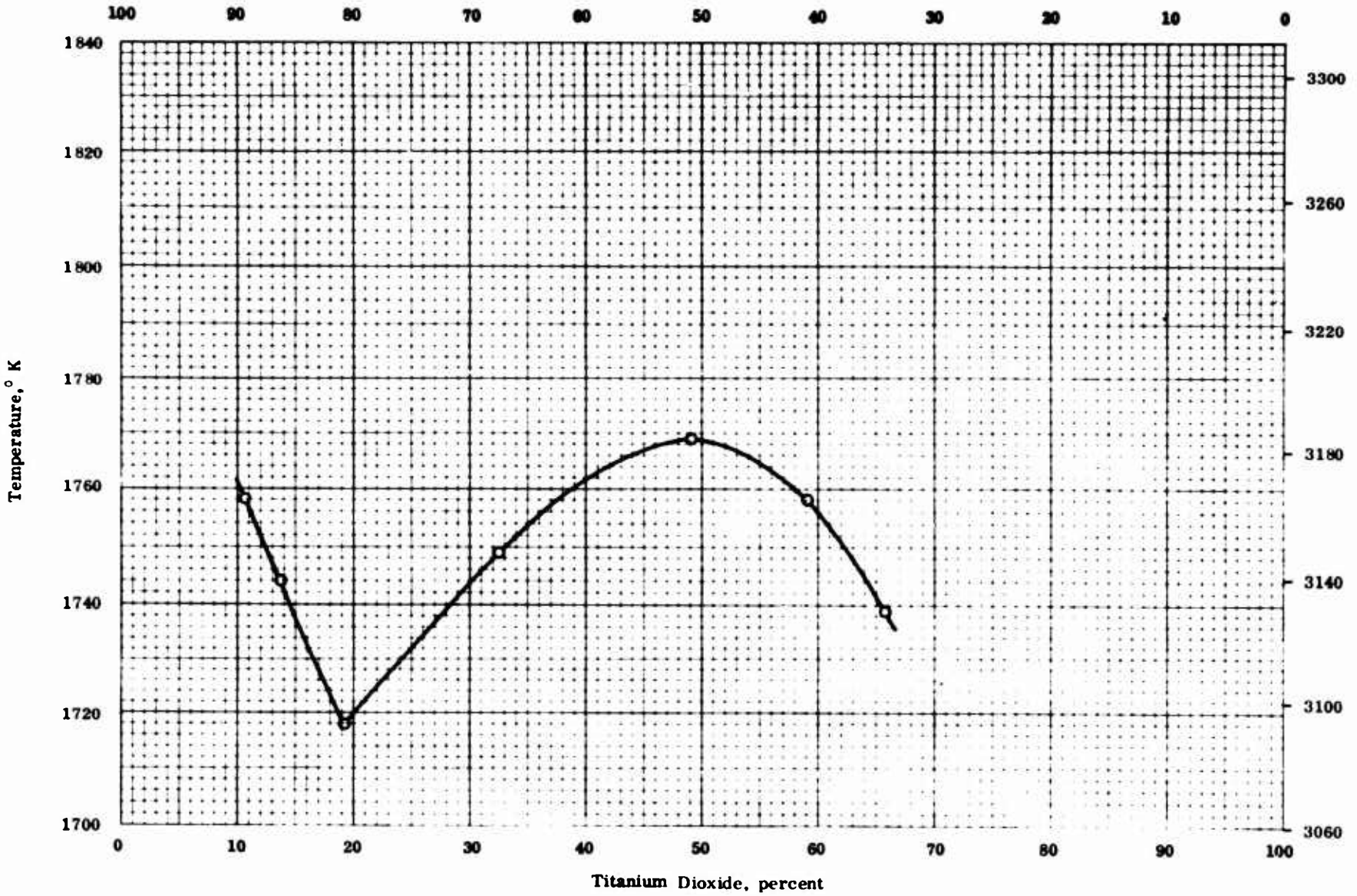


THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + MANGANESE DIOXIDE

THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + MANGANESE DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	60-36	300-1273		89.22 TiO_2 and 10.78 MnO_2; prepared from reagent grade MnO_2 and Titanium Pigment Corporation's Titanex TG with 0.01 > CaO, 0.1 > WO_3; 0.008 > Nb, 0.007 > Sb_2O_3, 0.04 > SiO_2, 0.006 Fe_2O_3, 0.001 V, 0.00005 Mn, 0.0005 Cu, 0.0004 Cr, and 0.001 - 0.002 Pb.	100 g TiO_2 and 12.08 g MnO_2 ball-milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15 binder (40 g Carbowax 20 M, 20 cc of 2 Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired to 1500 C for 17 hrs, cooled to room temperature in less than 30 min, and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
Δ	60-36	300-1273		Same as above.	Same as above except measured along c-axis.

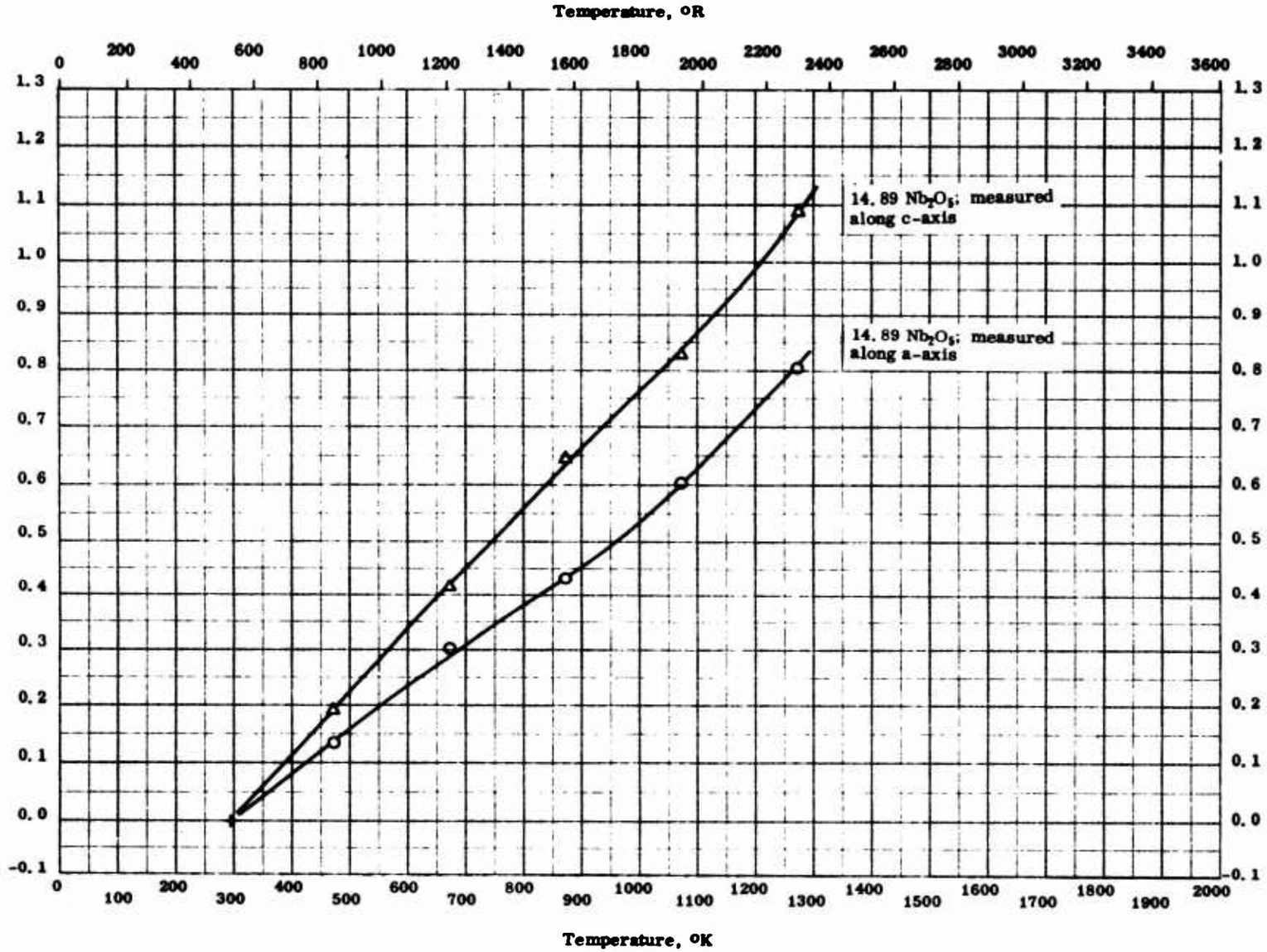


MELTING POINT -- TITANIUM DIOXIDE + NIOBIUM PENTOXIDE

MELTING POINT -- TITANIUM DIOXIDE + NIOBIUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	52-12	1718-1769		Prepared from 99.5 TiO_2 and 99.9 Nb_2O_5.	Sintered



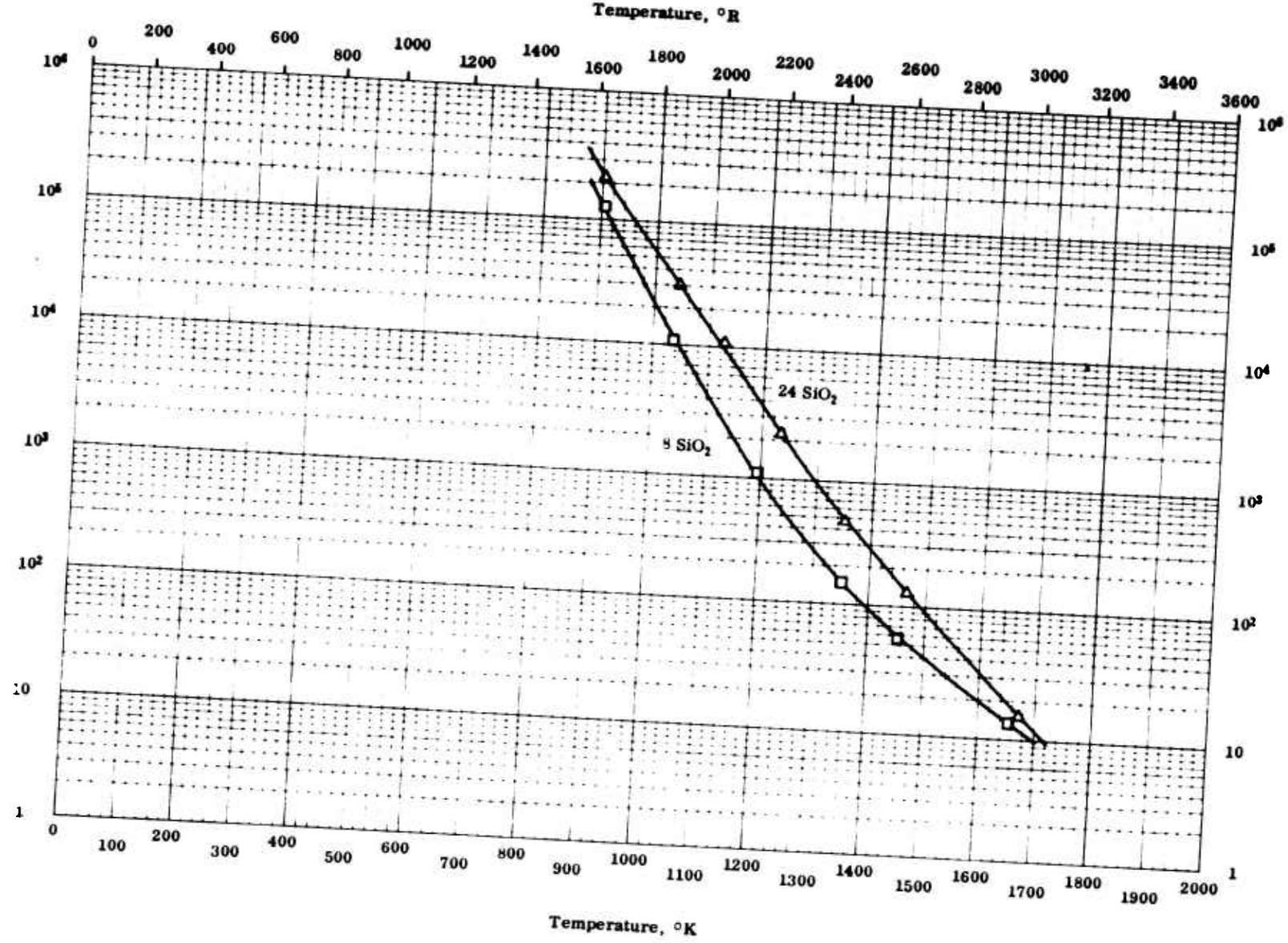
THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + NIOBIUM PENTOXIDE

TPRC

THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + NIOBIUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	60-36	301-1273		85.11 TiO_2 and 14.89 Nb_2O_5; prepared from reagent grade Nb_2O_5 and Titanium Pigment Corporation's Titanox TG with 0.01 > CaO, 0.1 > WO_3, 0.008 > Nb, 0.007 > Sb_2O_3, 0.04 > SiO_2, 0.006 Fe_2O_3, 0.001 V, 0.00005 Mn, 0.0005 Cu, 0.0004 Cr, and 0.001 - 0.002 Pb.	240 g TiO_2 and 42 g Nb_2O_5, ball-milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15 binder (40 g Carbowax 20 M, 20 cc of 2 Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired to 1400 C for 3 hrs, cooled to room temperature in less than 30 min, and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
Δ	60-36	301-1273		Same as above.	Same as above except measured along c-axis.

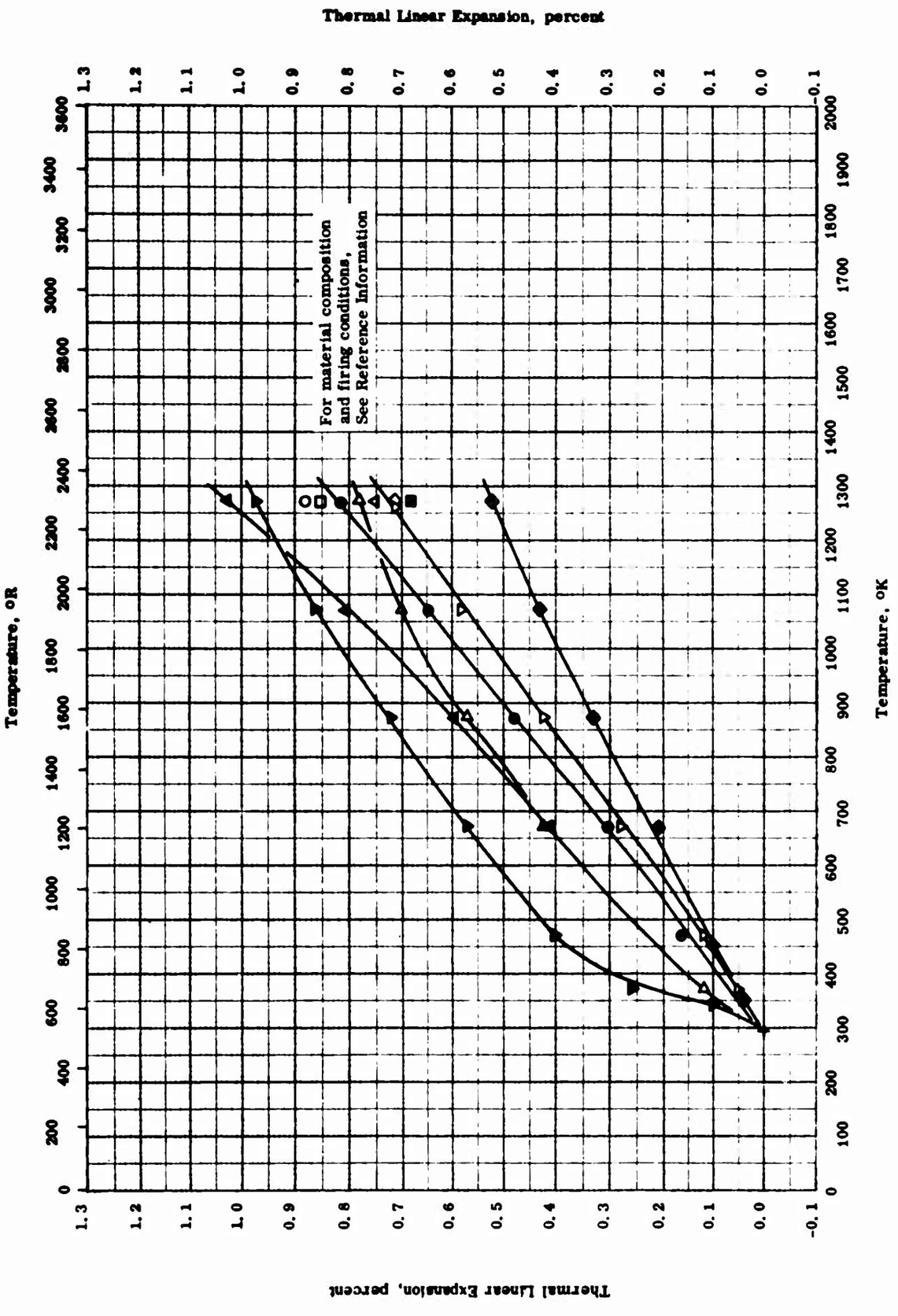


ELECTRICAL RESISTIVITY -- TITANIUM DIOXIDE + SILICON DIOXIDE

ELECTRICAL RESISTIVITY -- TITANIUM DIOXIDE + SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
□	53-17	903-1673		92 TiO_2 and 8 SiO_2.	Fired 24 hrs to 1450 C.
△	53-17	903-1673		76 TiO_2 and 24 SiO_2.	Same as above.



THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + SILICON DIOXIDE

THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
●	60-36	300-1273		76.00 TiO_2 and 24.00 SiO_2: prepared from reagent grade SiO_2 and Titanium Pigment Corporation's Titanox TG with < 0.01 CaO, < 0.1 WO_3, < 0.008 Nb, < 0.007 Sb_2O_3, < 0.04 SiO_2, 0.006 Fe_2O_3, 0.001 V, 0.00005 Mn, 0.0005 Cu, 0.0004 Cr, and 0.001 - 0.002 Pb.	152 g TiO_2 and 48 g SiO_2 ball-milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15 binder (40 g Carbowax 20 M, 20 cc of 2 Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired to 1500 C for 15 hrs, cooled to room temperature in less than 30 min, and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
▲	60-36	300-1273		Same as above.	Same as above except measured along c-axis.
○	51-25	293-1273		97 TiO_2 and 3 SiO_2.	Heated 2 hrs at 1540 C and 8 hrs at 1500 C.
□	51-45	293-1273		92 TiO_2 and 8 SiO_2.	Same as above.
△	51-25	293-1273		84 TiO_2 and 16 SiO_2.	Same as above.
◇	51-25	293-1273		76 TiO_2 and 24 SiO_2. [Author's design : Sample 1]	Same as above.
▽	51-25	373-1273		Same as above. [Author's design : Sample 2]	Same as above.
■	51-25	293-1273		67 TiO_2 and 33 SiO_2.	Same as above.
▼	51-25	343-1273		57 TiO_2 and 43 SiO_2.	Same as above.
◆	51-25	353-1273		Same as above.	Same as above except fired 1 hr at 1670 C.
▷	51-25	373-1273		56 TiO_2, 42 SiO_2, and 2 GeO_2.	Heated 2 hrs at 1540 C, 8 hrs at 1500 C, and fired 1 hr at 1540 C.

PROPERTIES OF TITANIUM DIOXIDE + STRONTIUM OXIDE

REPORTED VALUES

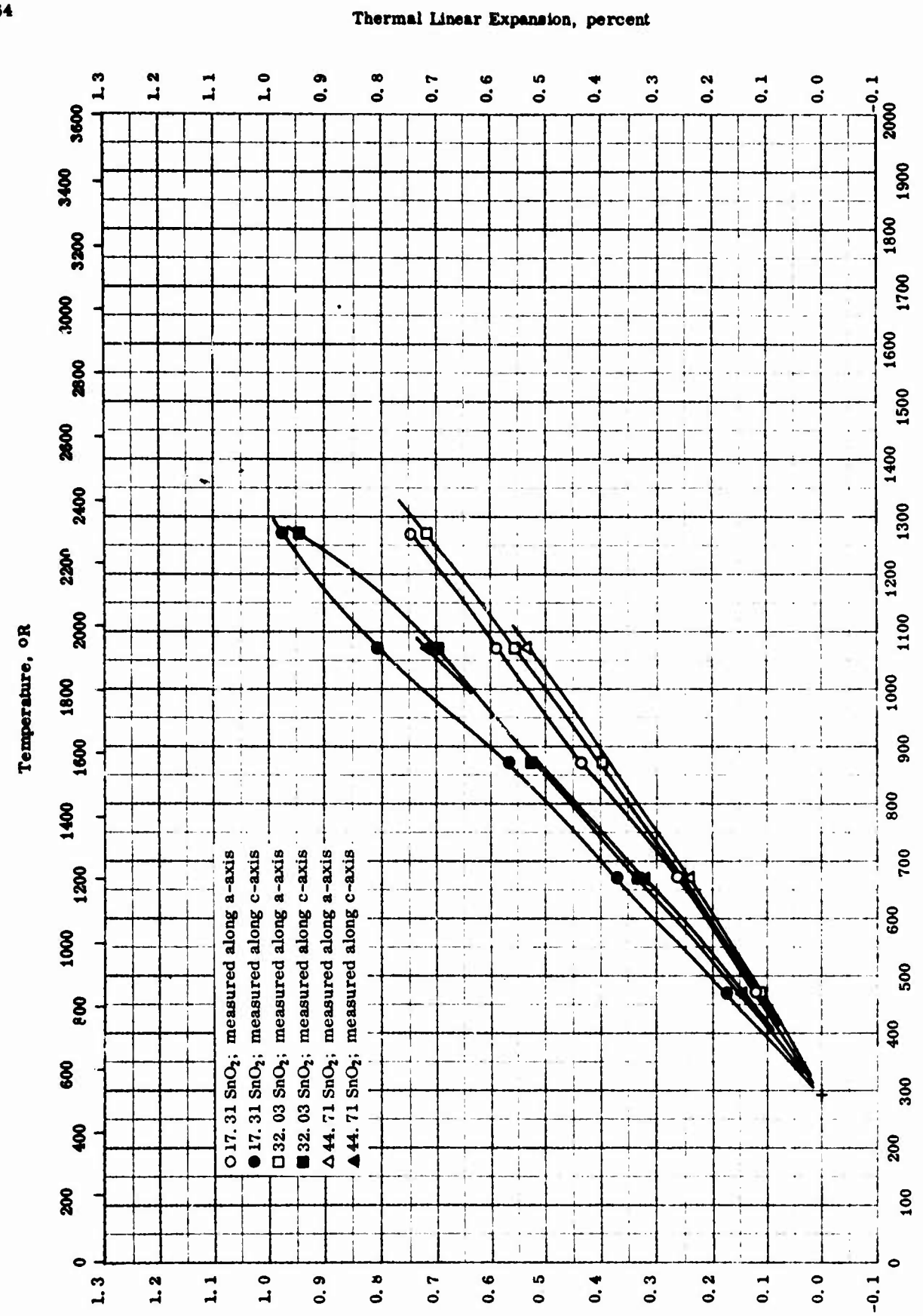
Melting Point	K	R
◇ 70 - 80 TiO_2.	1713 ±10	3084 ± 18

PROPERTIES OF TITANIUM DIOXIDE + STRONTIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◇	55-27	1703-1723		Eutectic between TiO_2 and $SrO \cdot TiO_2$ containing 70 - 80 TiO_2.	Presintered at 1100 C and sintered at 1350 - 1500 C; M. P. by visual observation.

THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + TIN (IC) OXIDE

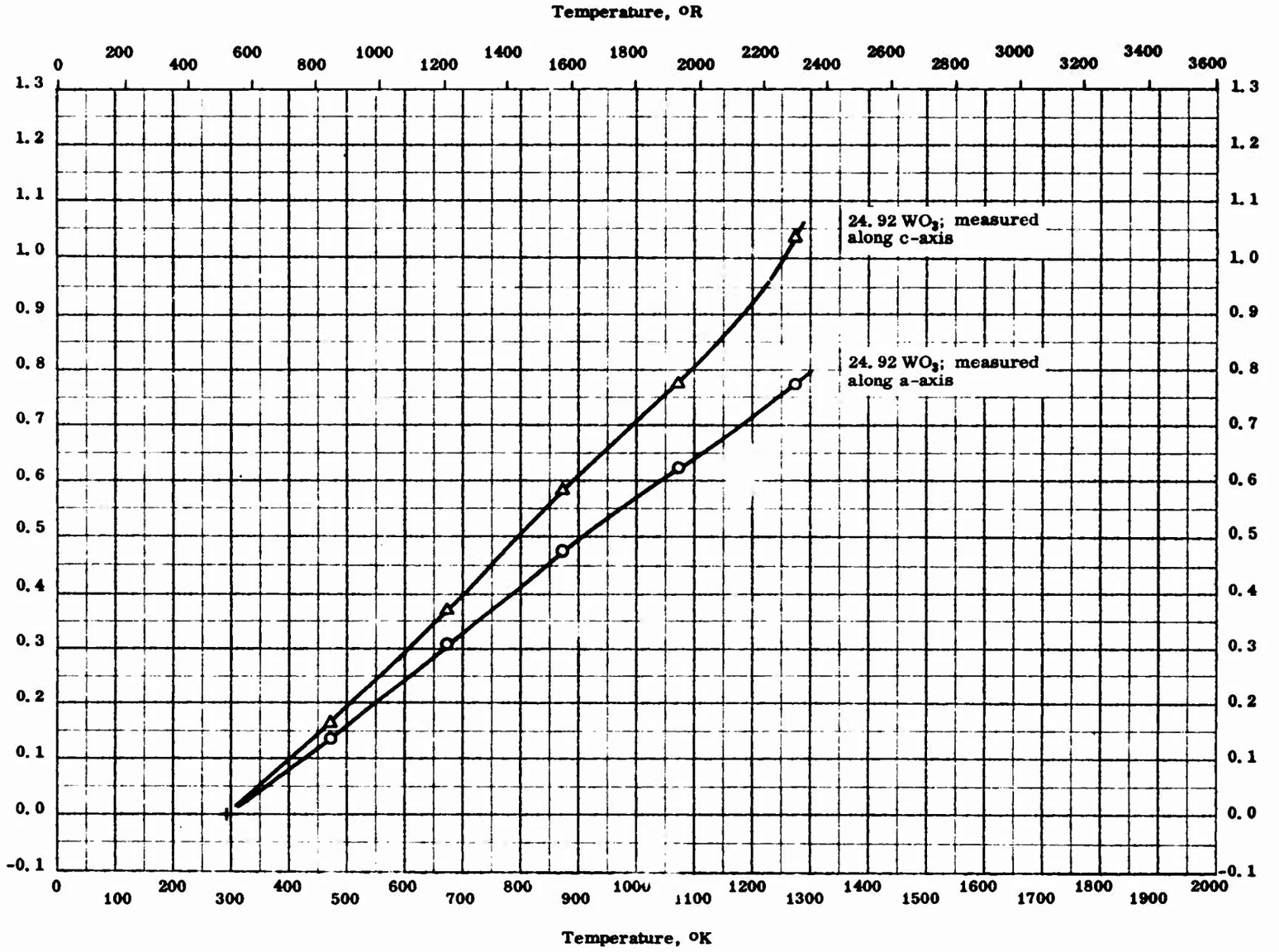


THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + TIN (IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	60-36	299-1273		82.69 TiO_2 and 17.31 SnO_2; prepared from reagent grade SnO_2 and Titanium Pigment Corporation's Titanox TG with < 0.01 CaO, < 0.1 WO_3, < 0.008 Nb, < 0.007 Sb_2O_3, < 0.04 SiO_2, 0.006 Fe_2O_3, 0.001 V, 0.00005 Mn, 0.0005 Cu, 0.0004 Cr, and 0.001 - 0.002 Pb.	80 g TiO_2 and 16.75 g SnO_2 ball-milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15 binder (40 g Carbowax 20 M, 20 cc of 2 Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired to 1500 C for 17 hrs, cooled to room temperature in less than 30 min, and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
●	60-36	299-1273		Same as above.	Same as above except measured along c-axis.
□	60-36	299-1273		67.97 TiO_2 and 32.03 SnO_2; raw materials same as above.	Same as above except measured along a-axis.
■	60-36	299-1273		Same as above.	Same as above except measured along c-axis.
△	60-36	298-1073		55.29 TiO_2 and 44.71 SnO_2; raw materials same as above.	Same as above except measured along a-axis.
▲	60-36	298-1073		Same as above.	Same as above except measured along c-axis.

TPRC



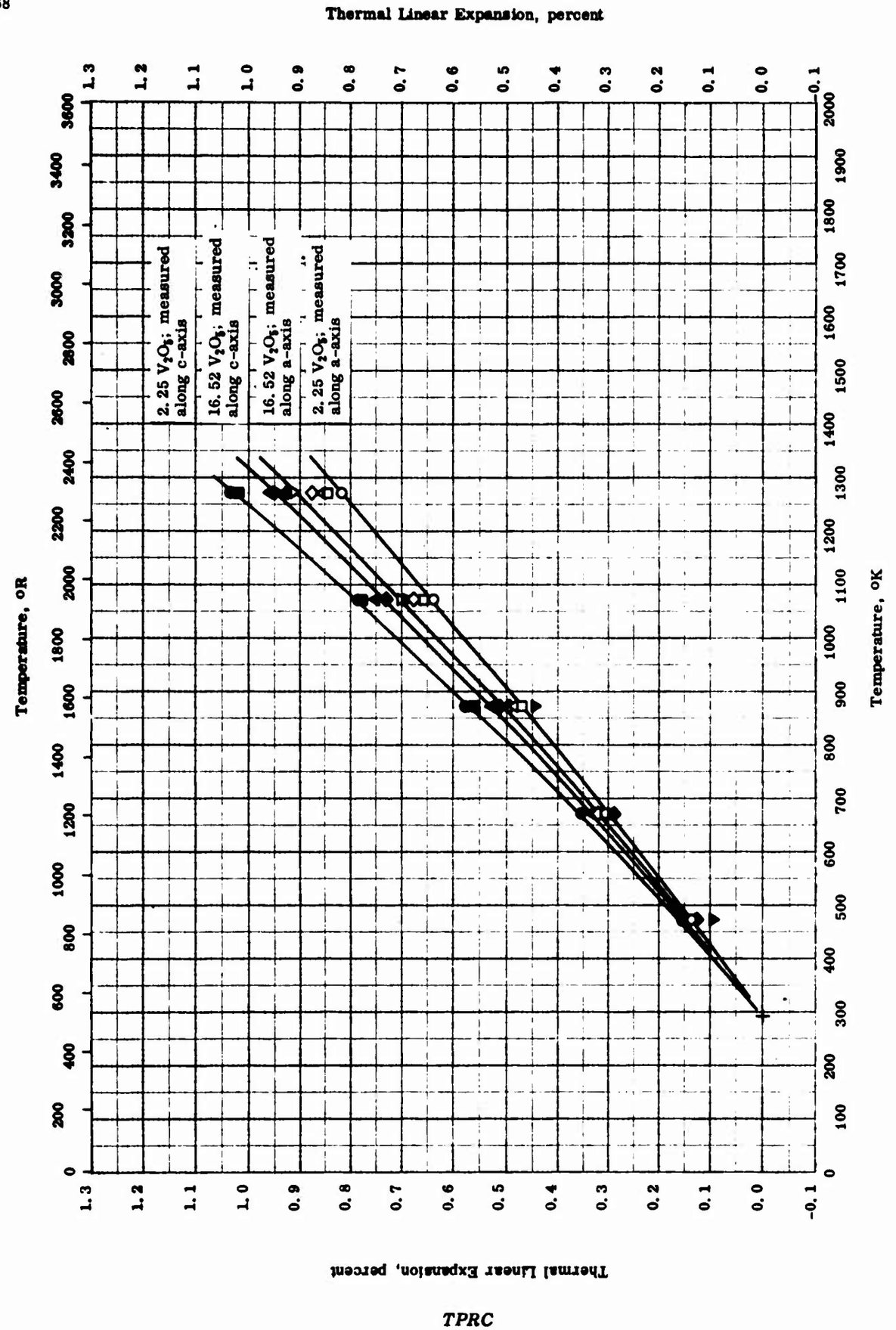
THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + TUNGSTEN TRIOXIDE

TPRC

THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + TUNGSTEN TRIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	60-36	299-1273		75.08 TiO_2 and 24.92 WO_3; prepared from reagent grade WO_3 and Titanium Pigment Corporation's Titanox TG with 0.01> CaO, 0.1> WO_3, 0.008> Nb, 0.007> Sb_2O_3, 0.04> SiO_2, 0.006 Fe_2O_3, 0.001 V, 0.00005 Mn, 0.0005 Cu, 0.0004 Cr, and 0.001 - 0.002 Pb.	100 g TiO_2 and 33.2 g WO_3 ball-milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15 binder (40 g Carbowax 20 M, 20 cc of 2 Methocel solution and 40 cc H_2O), dried at 110C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired to 1500 C for 17 hrs, cooled to room temperature in less than 30 min, and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
Δ	60-36	299-1273		Same as above.	Same as above except measured along c-axis.

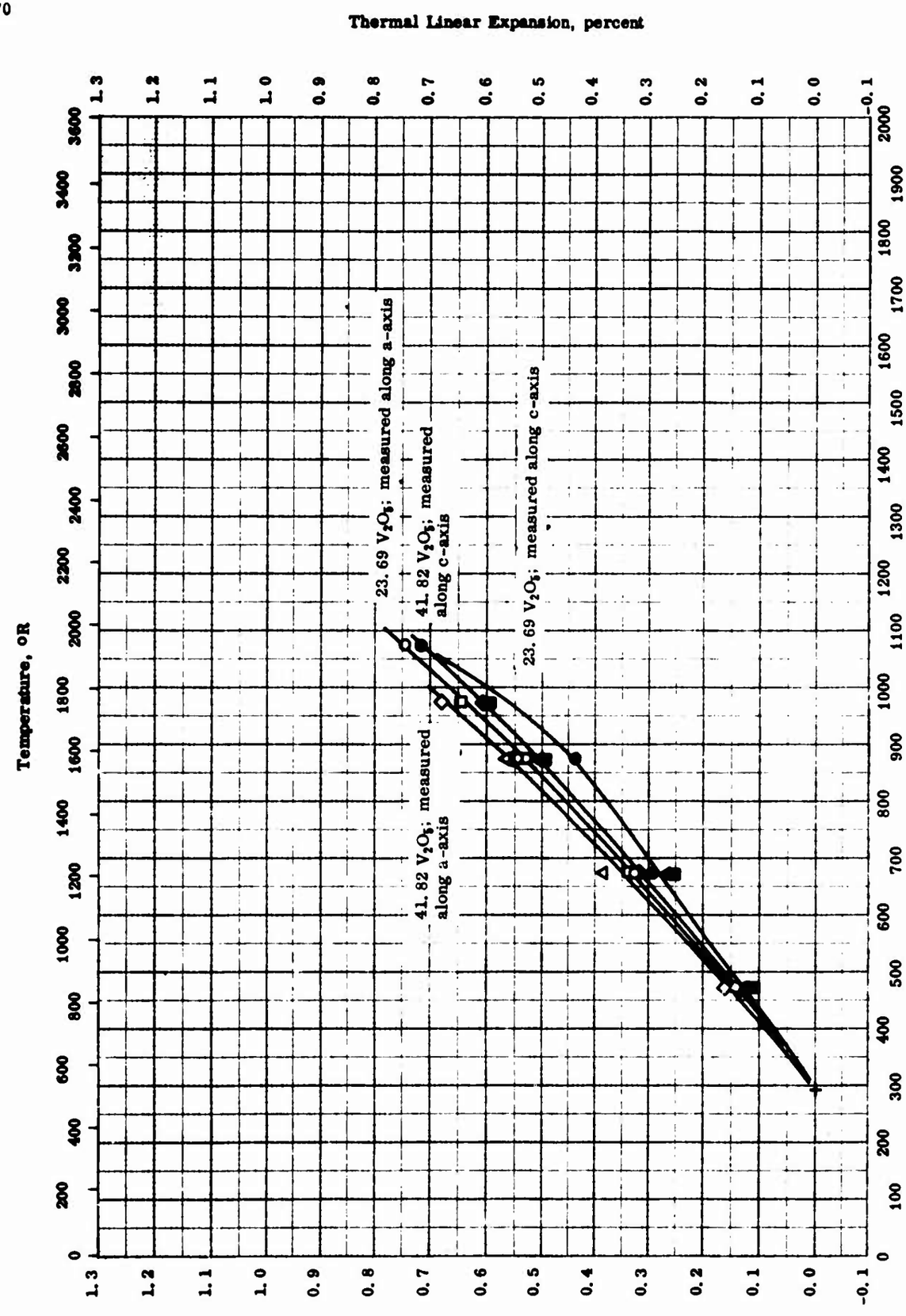


THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + VANADIUM PENTOXIDE
($2 < V_2O_5 < 17$)

THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + VANADIUM PENTOXIDE
($2 < V_2O_5 < 17$)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	60-42	297-1273		97.75 TiO_2 and 2.25 V_2O_5; prepared from reagent grade V_2O_5 and Titanium Pigment Corporation's Titanox TG with < 0.01 CaO, < 0.1 WO_3, < 0.008 Nb, < 0.007 Sb_2O_3, < 0.04 SiO_2, 0.006 Fe_2O_3, 0.001 V, 0.00005 Mn, 0.0005 Cu, 0.0004 Cr, and 0.001 - 0.002 Pb.	156.40 g TiO_2, and 3.60 g V_2O_5, ball-milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15 binder (40 g Carbowax 20 M, 20 cc of 2 Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired to 1200 C for 17 hrs, cooled to room temperature in less than 30 min, and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
●	60-42	297-1273		Same as above.	Same as above except measured along c-axis.
□	60-42	299-1273		95.56 TiO_2 and 4.44 V_2O_5; raw materials same as above.	Same as above except measured along a-axis.
■	60-42	299-1273		Same as above.	Same as above except measured along c-axis.
△	60-42	297-1273		91.36 TiO_2 and 8.64 V_2O_5; raw materials same as above.	Same as above except measured along a-axis.
▲	60-42	297-1273		Same as above.	Same as above except measured along c-axis.
◇	60-36	300-1273		88.78 TiO_2 and 11.22 V_2O_5; raw materials same as above.	Same as above except measured along a-axis and fired to 1200 C for 18 hrs.
◆	60-36	300-1273		Same as above.	Same as above except measured along c-axis.
▽	60-42	296-1273		83.48 TiO_2 and 16.52 V_2O_5; raw materials same as above.	Same as above except measured along a-axis and fired to 1200 C for 17 hrs.
▼	60-42	296-1273		Same as above.	Same as above except measured along c-axis.



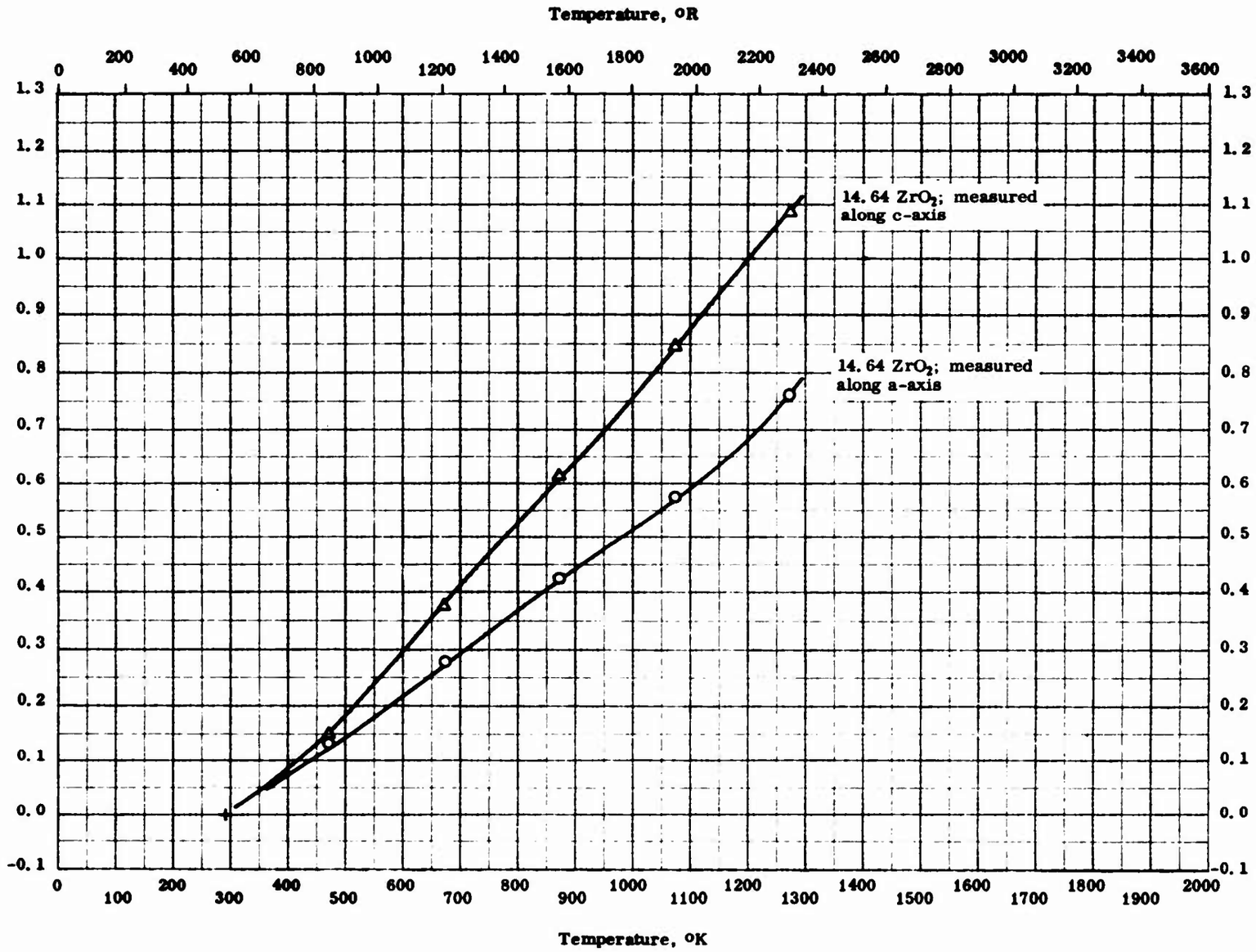
THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + VANADIUM PENTOXIDE
($23 < V_2O_5 < 42$)

THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + VANADIUM PENTOXIDE
($23 < V_2O_5 < 42$)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	60-42	296-1073		76.31 TiO_2 and 23.69 V_2O_5; prepared from reagent grade V_2O_5 and Titanium Pigment Corporation's Titanox TG with 0.01> CaO, 0.1> WO_3, 0.008> Nb, 0.007> Sb_2O_3, 0.04> SiO_2, 0.006 Fe_2O_3, 0.001 V, 0.00005 Mn, 0.0005 Cu, 0.0004 Cr, and 0.001 - 0.002 Pb.	TiO_2 and V_2O_5 ball-milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15 binder (40 g Carbowax 20 M, 20 cc of 2 Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired to 800 C for 7 hrs, cooled to room temperature in less than 30 min, and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
●	60-42	296-1073		Same as above.	Same as above except measured along c-axis.
□	60-42	296-973		69.76 TiO_2 and 30.24 V_2O_5; raw materials same as above.	Same as above except measured along a-axis and fired to 1200 C for 17 hrs.
■	60-42	296-973		Same as above.	Same as above except measured along c-axis.
△	60-42	297-873		63.74 TiO_2 and 36.26 V_2O_5; raw materials same as above.	Same as above except measured along a-axis.
▲	60-42	297-873		Same as above.	Same as above except measured along c-axis.
◇	60-42	296-973		58.18 TiO_2 and 41.82 V_2O_5; raw materials same as above.	Same as above except measured along a-axis.
◆	60-42	296-973		Same as above.	Same as above except measured along c-axis.

TPRC



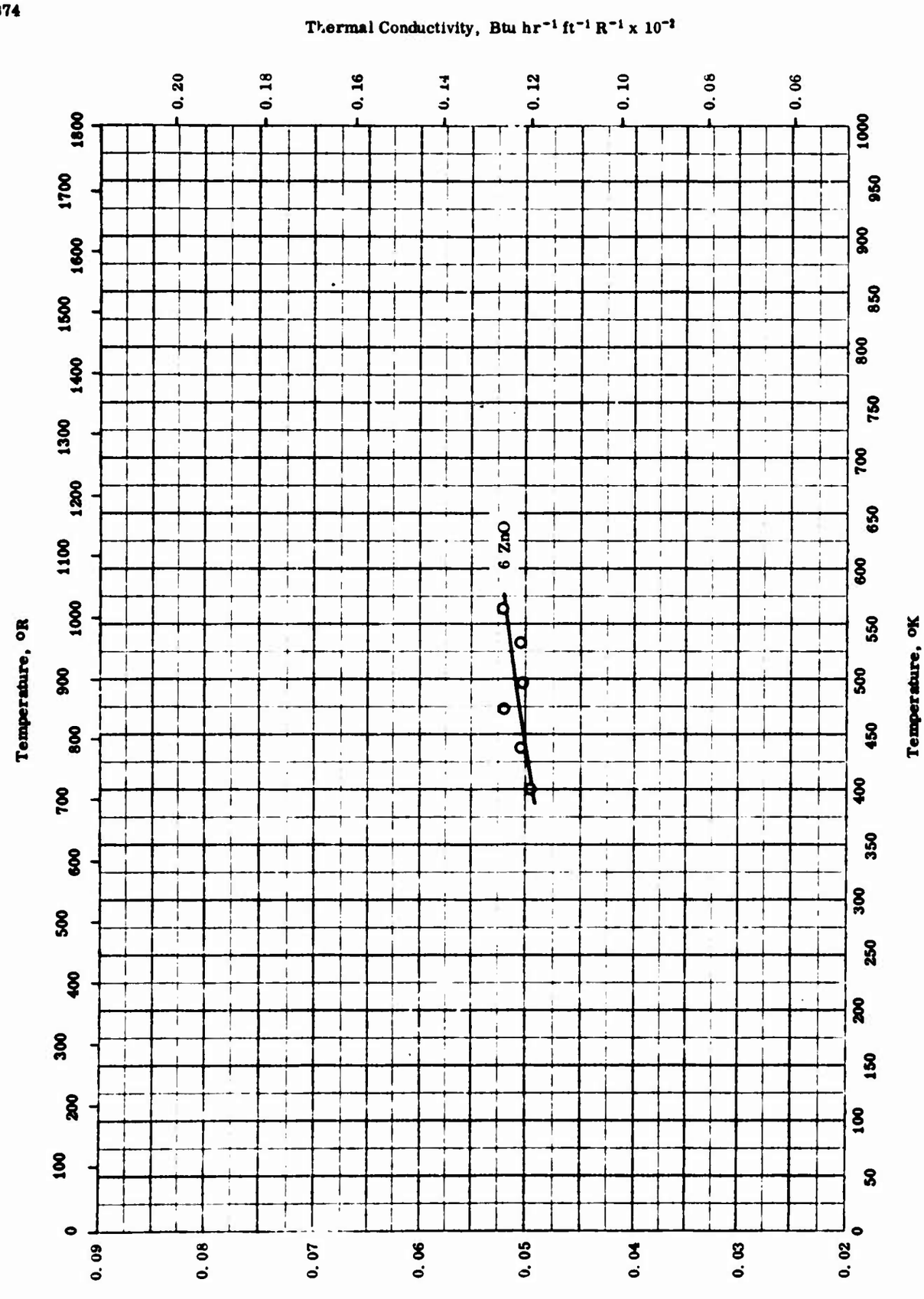
THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + ZIRCONIUM DIOXIDE

THERMAL LINEAR EXPANSION -- TITANIUM DIOXIDE + ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	60-36	297-1273		85.36 TiO_2 and 14.64 ZrO_2; prepared from reagent grade ZrO_2 and Titanium Pigment Corporation's Titanox TG with < 0.01 CaO, < 0.1 WO_3, < 0.008 Nb, < 0.007 Sb_2O_3, < 0.04 SiO_2, 0.006 Fe_2O_3, 0.001 V, 0.00005 Mn, 0.0005 Cu, 0.0004 Cr, and 0.001 - 0.002 Pb.	100 g TiO_2 and 17.15 g ZrO_2 ball-milled for 4 hrs, passed through a 4 mesh standard screen, mixed with 15 binder (40 g Carbowax 20 M, 20 cc of 2 Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired to 1500 C for 17 hrs, cooled to room temperature in less than 30 min, and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
Δ	60-36	297-1273		Same as above.	Same as above except measured along c-axis.

TPRC



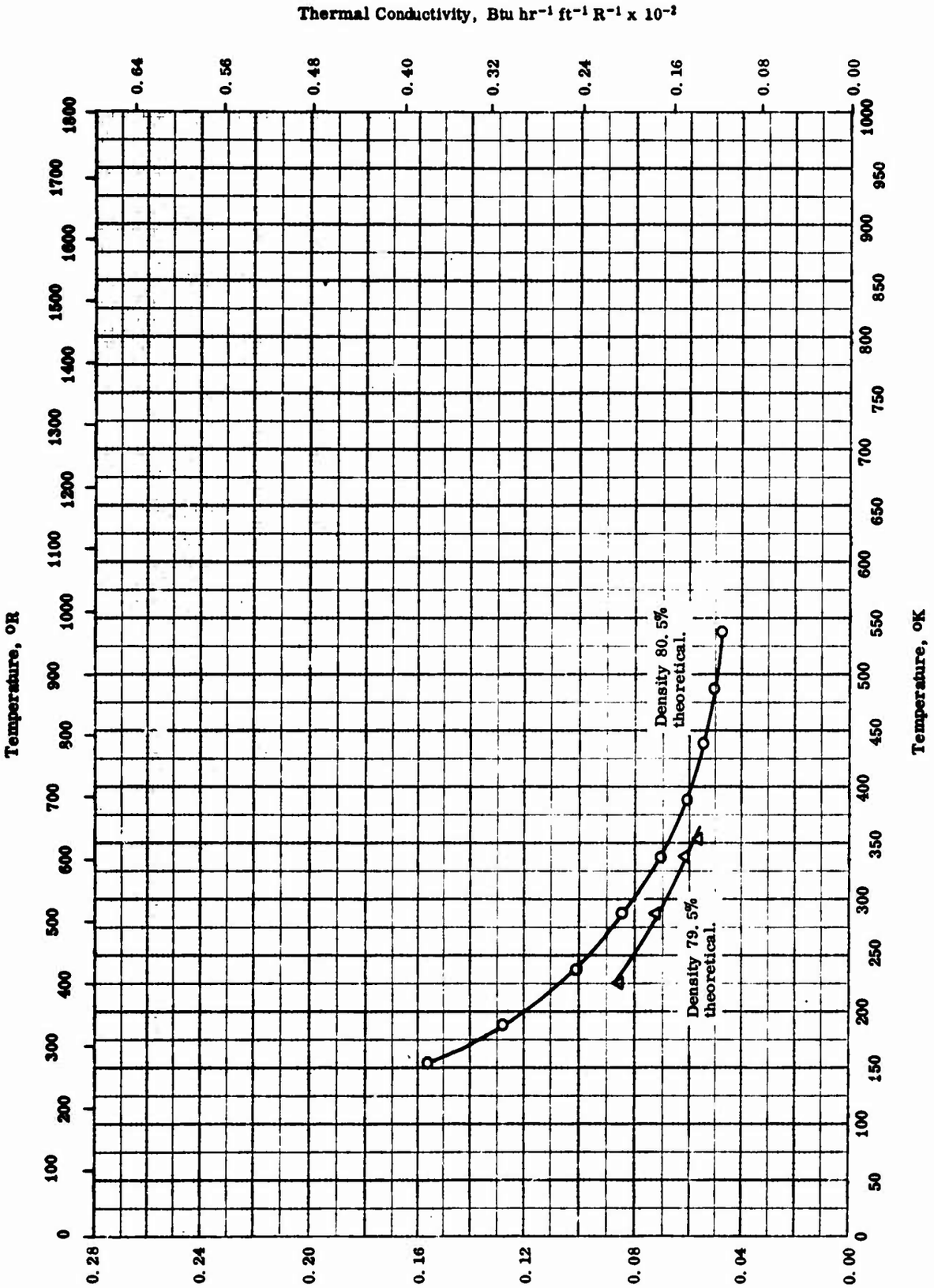
THERMAL CONDU -- TUNGSTEN TRIOXIDE + ZINC OXIDE

THERMAL CONDUCTIVITY -- TUNGSTEN TRIOXIDE + ZINC OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	55-10	400-564		6.0 ZnO; coarse crystalline structure; considerable porosity.	Prepared by firing H_2WO_4 and ZnO.

TPRC

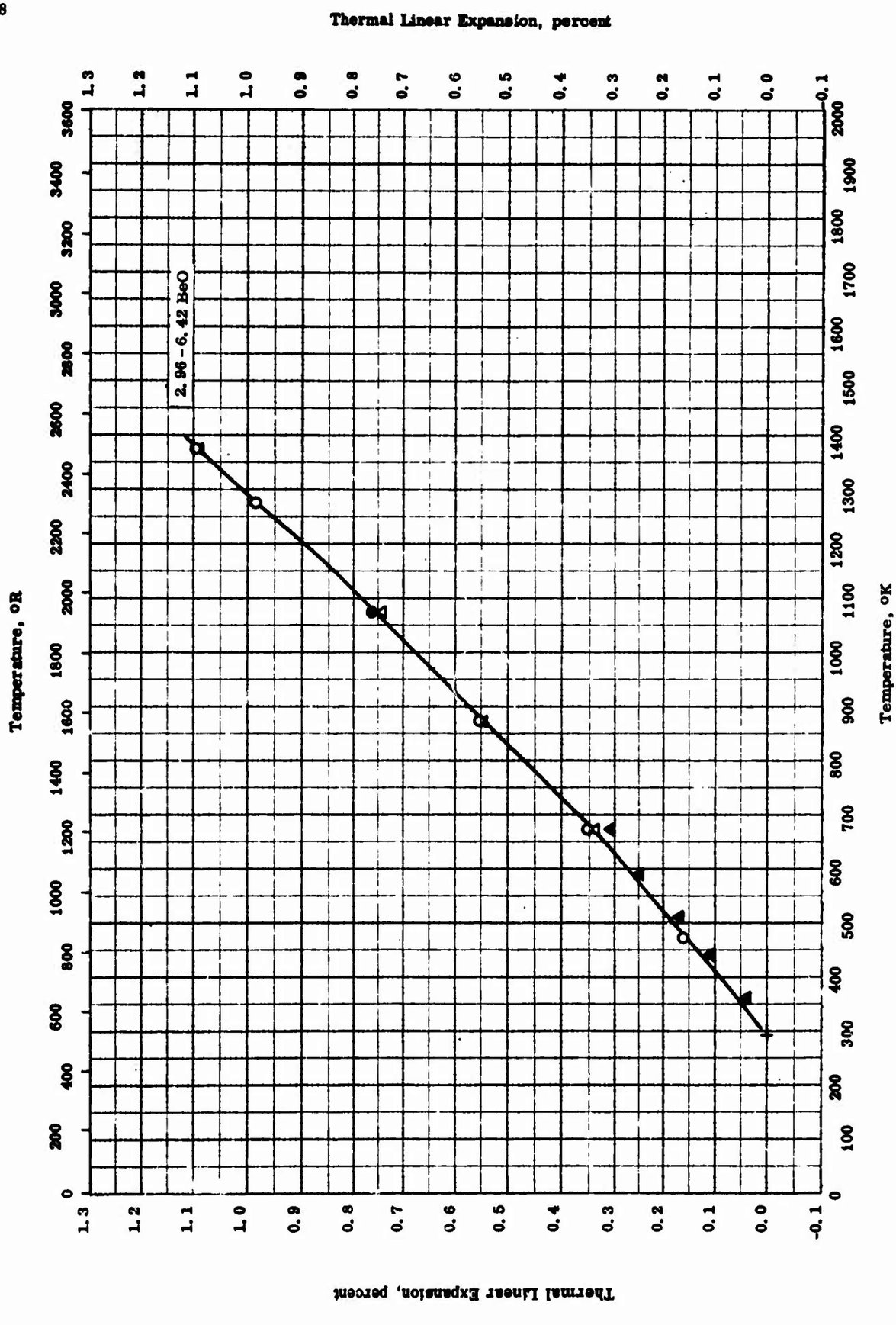


THERMAL CONDUCTIVITY -- URANIUM DIOXIDE + BERYLLIUM OXIDE

THERMAL CONDUCTIVITY -- URANIUM DIOXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-3	308-1075		70.9 UO_2 and 29.1 BeO; density 80.5% of theoretical.	Sintered.
Δ	57-3	450-708		Same as above; density 79.5% of theoretical.	Same as above.

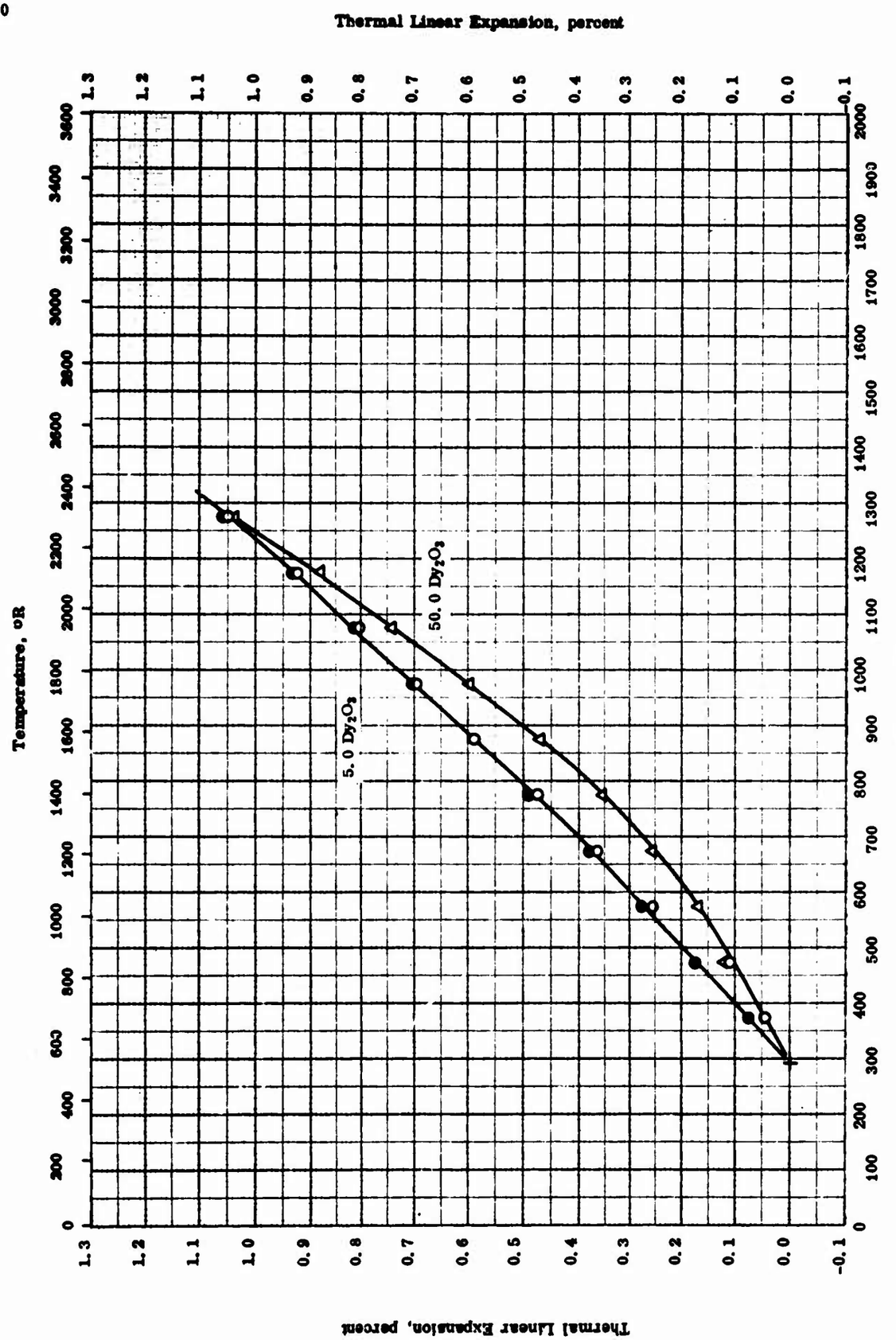


THERMAL LINEAR EXPANSION -- URANIUM DIOXIDE + BERYLLIUM OXIDE

THERMAL LINEAR EXPANSION -- URANIUM DIOXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	62-37	293-1373		97.04 UO_2 and 2.96 BeO (calculated composition based on theoretical density and zero porosity).	
●	62-37	293-1373		95.38 UO_2 and 4.62 BeO (calculated composition based on theoretical density and zero porosity).	
△	62-37	293-1373		93.58 UO_2 and 6.42 BeO (calculated composition based on theoretical density and zero porosity).	
▲	52-25	293-673		70.9 UO_2 and 29.1 BeO; 80% theoretical density.	Pressed from powder and sintered at 1850 C; measured in argon atm.

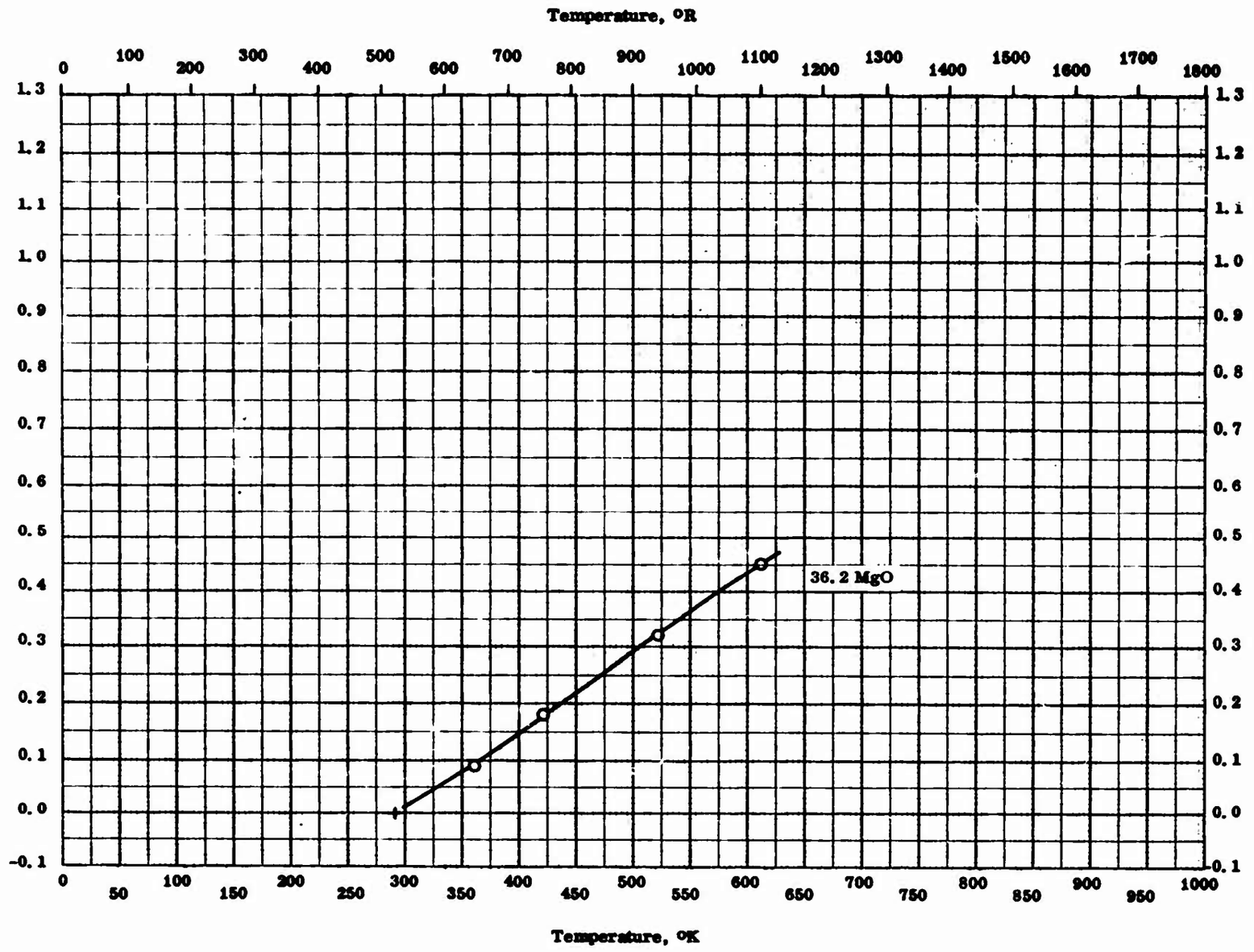


THERMAL LINEAR EXPANSION -- URANIUM DIOXIDE + DYSPROSIUM OXIDE

THERMAL LINEAR EXPANSION -- URANIUM DIOXIDE + DYSPROSIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	60-38	303-1273		95.0 UO_2 and 5.0 Dy_2O_3; bulk density 10.13 g cm^{-3}; one phase face centered cubic solid solution.	Wet ball milled with flint pebbles for 2 hrs, dry pressed at 20,000 psi with 2 soluble wax emulsion into pellets 1/2 in. in diameter by 1 in. long, and fired at 1750 C for 1 hr in H_2 atm.
●	60-38	303-1273		Same as above.	Same as above.
△	60-38	303-1273		50.0 UO_2 and 50.0 Dy_2O_3; one phase face centered cubic solid solution.	Same as above.



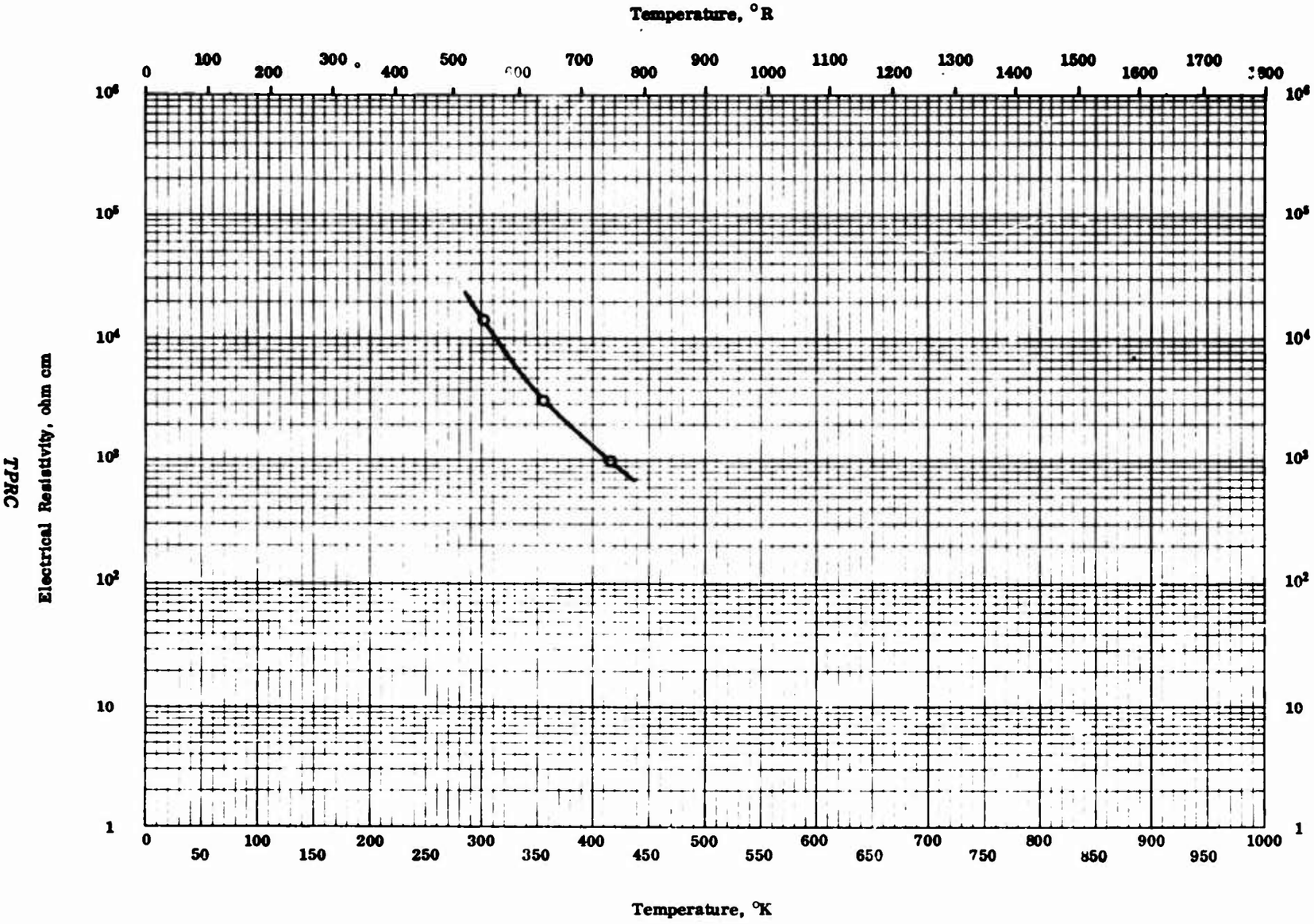
TPRC

THERMAL LINEAR EXPANSION -- URANIUM DIOXIDE + MAGNESIUM OXIDE

THERMAL LINEAR EXPANSION -- URANIUM DIOXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	52-25	293-613		63.8 UO_2 and 36.2 MgO; 80% of theoretical density.	Pressed from powders and sintered; measured in argon atm.



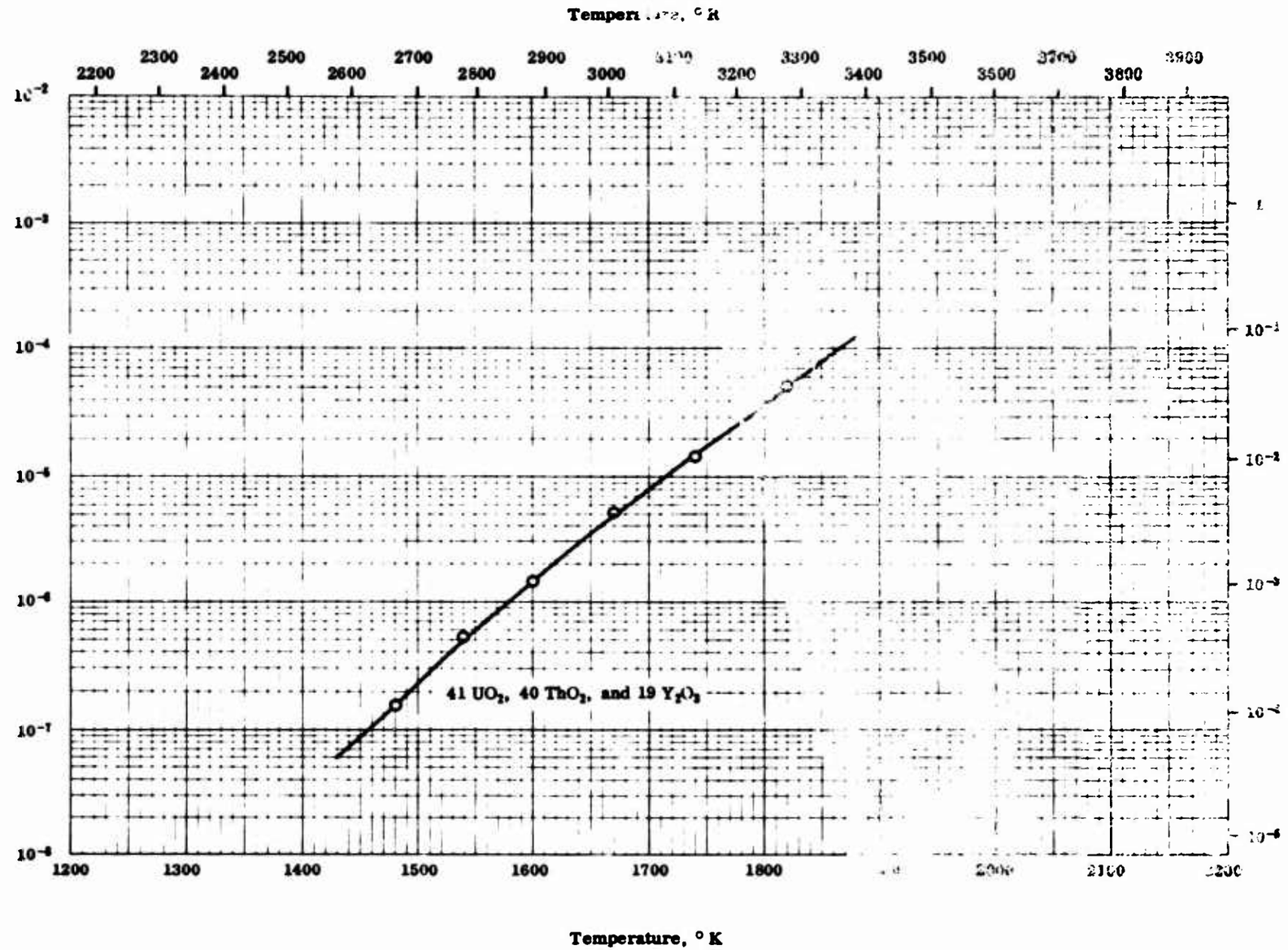
TPRC

ELECTRICAL RESISTIVITY -- URANIUM DIOXIDE + THORIUM DIOXIDE

ELECTRICAL RESISTIVITY -- URANIUM DIOXIDE + THORIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-24	303-417		50 UO_2 and 50 ThO_2; mixed from elements with 0.01 > transition and rare earth metals.	Pressed, and fired 8 hr at 1750 C in H_2.

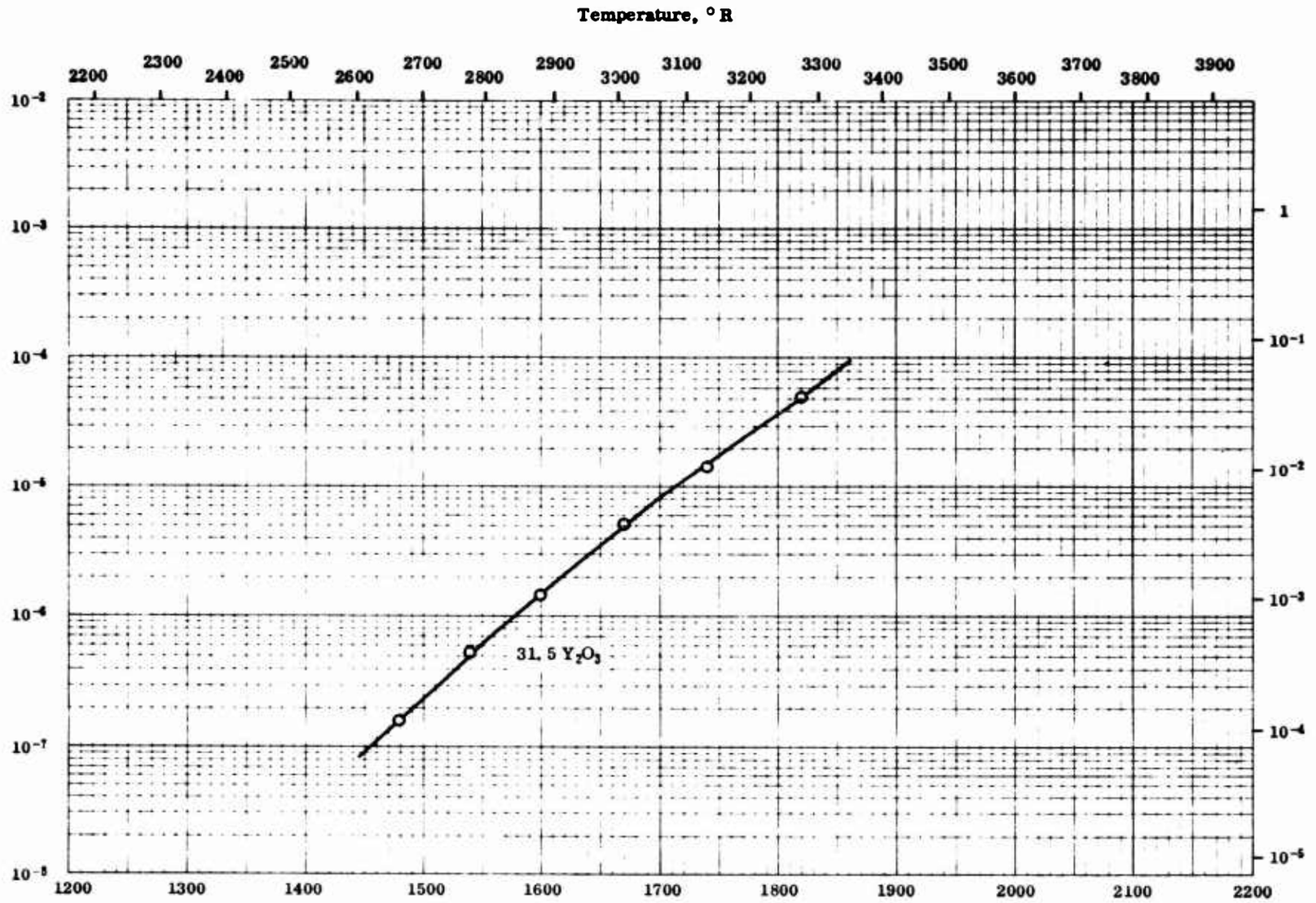


TPRC

VAPOR PRESSURE -- URANIUM DIOXIDE + THORIUM DIOXIDE + YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	64-4	1480-1820		41.02 UO_2, 40.11 ThO_2, and 18.87 Y_2O_3.	Corresponding to UO_2: ThO_2: Y_2O_3; mixed and reacted for 1 hr in air at 1850 C.



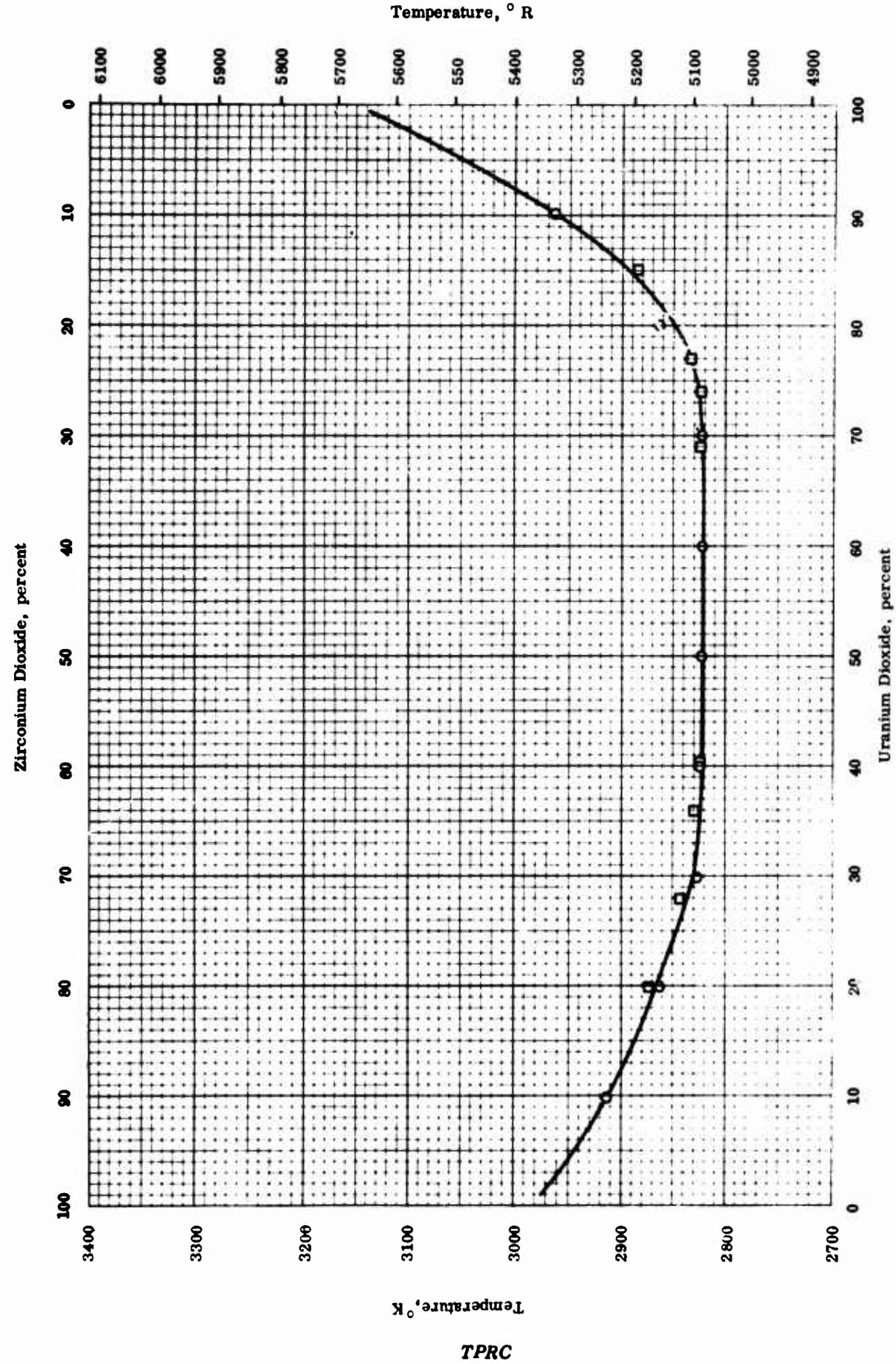
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VAPOR PRESSURE -- URANIUM DIOXIDE + YTTRIUM OXIDE

VAPOR PRESSURE -- URANIUM DIOXIDE + YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	64-4	1480-1820		68.50 UO_2 and 31.50 Y_2O_3.	Corresponding to UO_2: 0.55Y_2O_3; mixed and reacted for 1 hr in air at 1850 C.

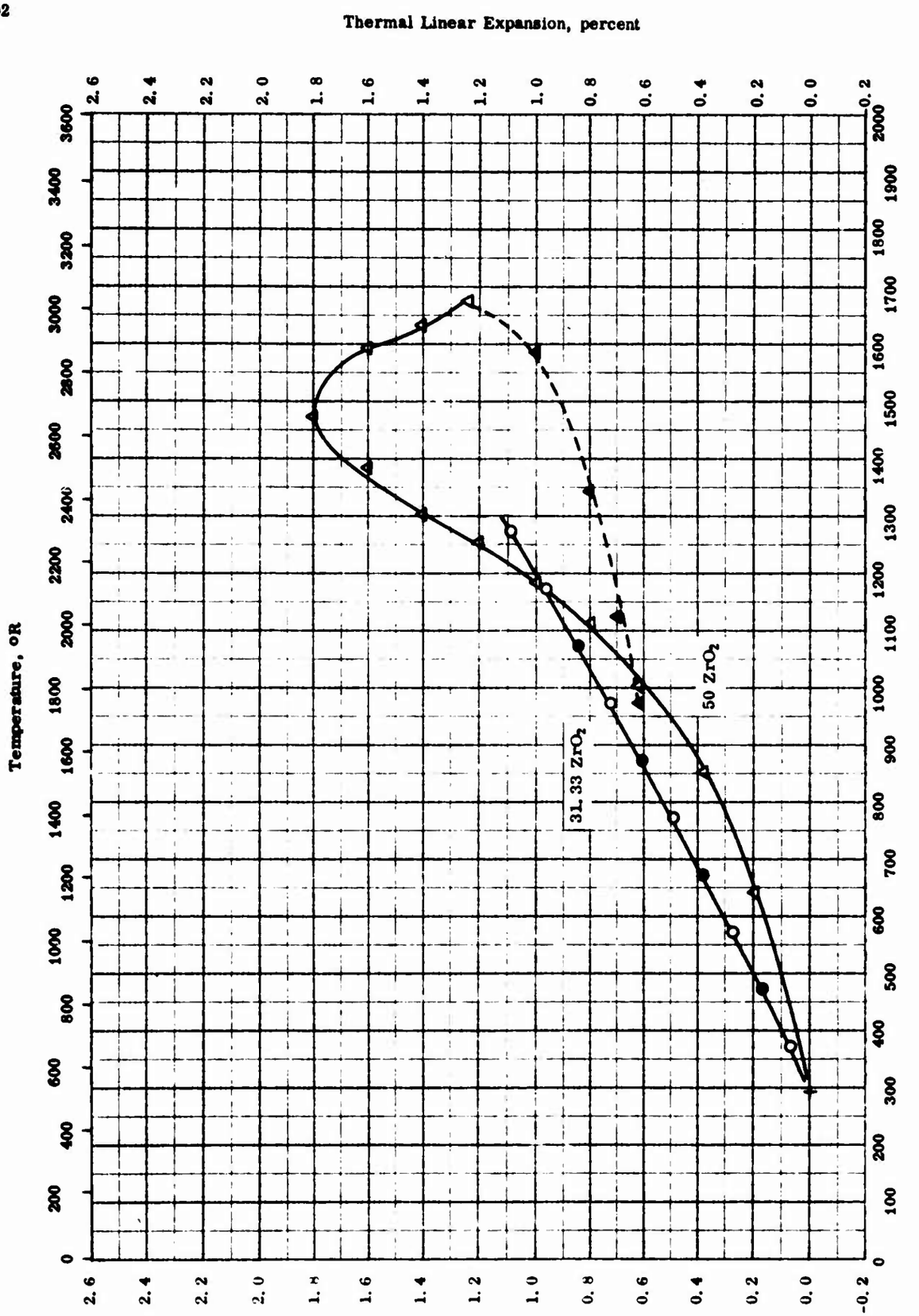


MELTING POINT -- URANIUM DIOXIDE + ZIRCONIUM DIOXIDE

MELTING POINT -- URANIUM DIOXIDE + ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-28	2823-3148		0-100 ZrO_2; prepared from ≈ 98 ZrO_2 (with 2 Hf and 0.035 other impurities) and probably pure UO_2.	
□	53-28	2823-2883		Same as above.	

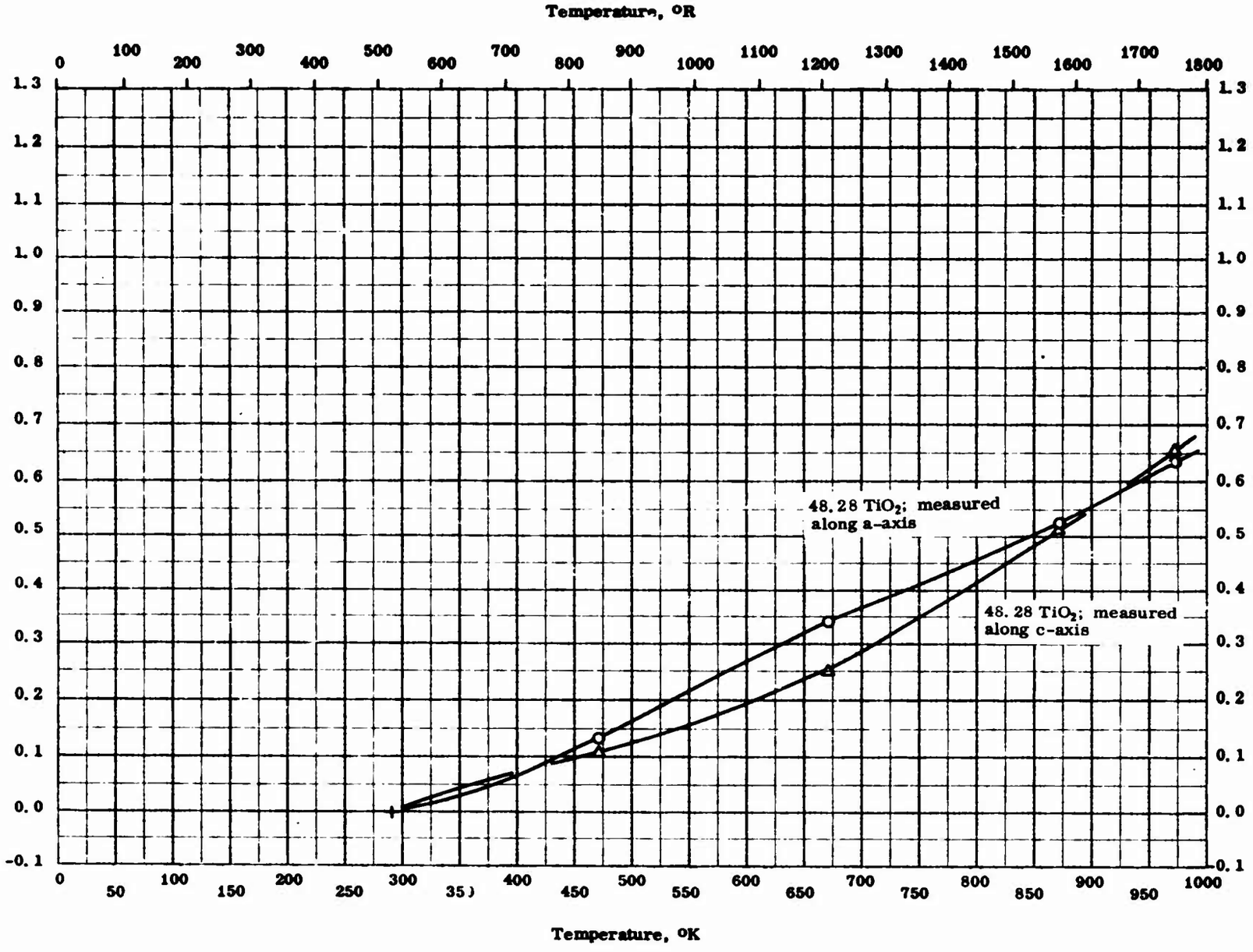


THERMAL LINEAR EXPANSION -- URANIUM DIOXIDE + ZIRCONIUM DIOXIDE

THERMAL LINEAR EXPANSION -- URANIUM DIOXIDE + ZIRCONIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	64-30	293-1273	±2	68.67 UO_2 and 31.33 ZrO_2; 98.5% of theoretical density. [Author's design : Specimen LE-188]	Cold isostatic pressed, sintered in flowing dry hydrogen at 1700 C for 20 hrs, ground into 0.25 in. in diameter by 3 in. long rod, cleaned in ethyl alcohol, and outgassed in vacuum at room temperature; measured in vacuum of approx. 2×10^{-5} mm of Hg with heating rate of 3 C min^{-1}; no hysteresis noted by author during cooling.
●	64-30	293-1273	±2	Same as above. [Author's design : Specimen TC-215]	Same as above except exposed to several heating and cooling cycles for thermal conductivity measurements.
△	57-41	273-1673		50 UO_2 and 50 ZrO_2; UO_2 prepared by heating U_3O_8 1 hr at 650 C in H_2 atm; ZrO_2 analysis: 97.0 ZrO_2, 0.57 SiO_2, 0.40 H_2O, 0.23 TiO_2, 0.16 Fe_2O_3, 1.61 ignition loss, and trace of MgO and CaO.	Components dry mixed in agate mortar, 5 dextrolyne added as binder, pressed at 1000 kg cm^{-2}, fired to 1700 C in 5-1/2 hrs, soaked 1 hr, and cooled overnight; heated to 1000 C at 10 C min^{-1}, 1000 - 1400 C at 7 C min^{-1}; cooled to 800 C at 10 C min^{-1} then to room temperature naturally.
▲	57-41	973-1673		Same as above.	Cooling cycle for above sample.

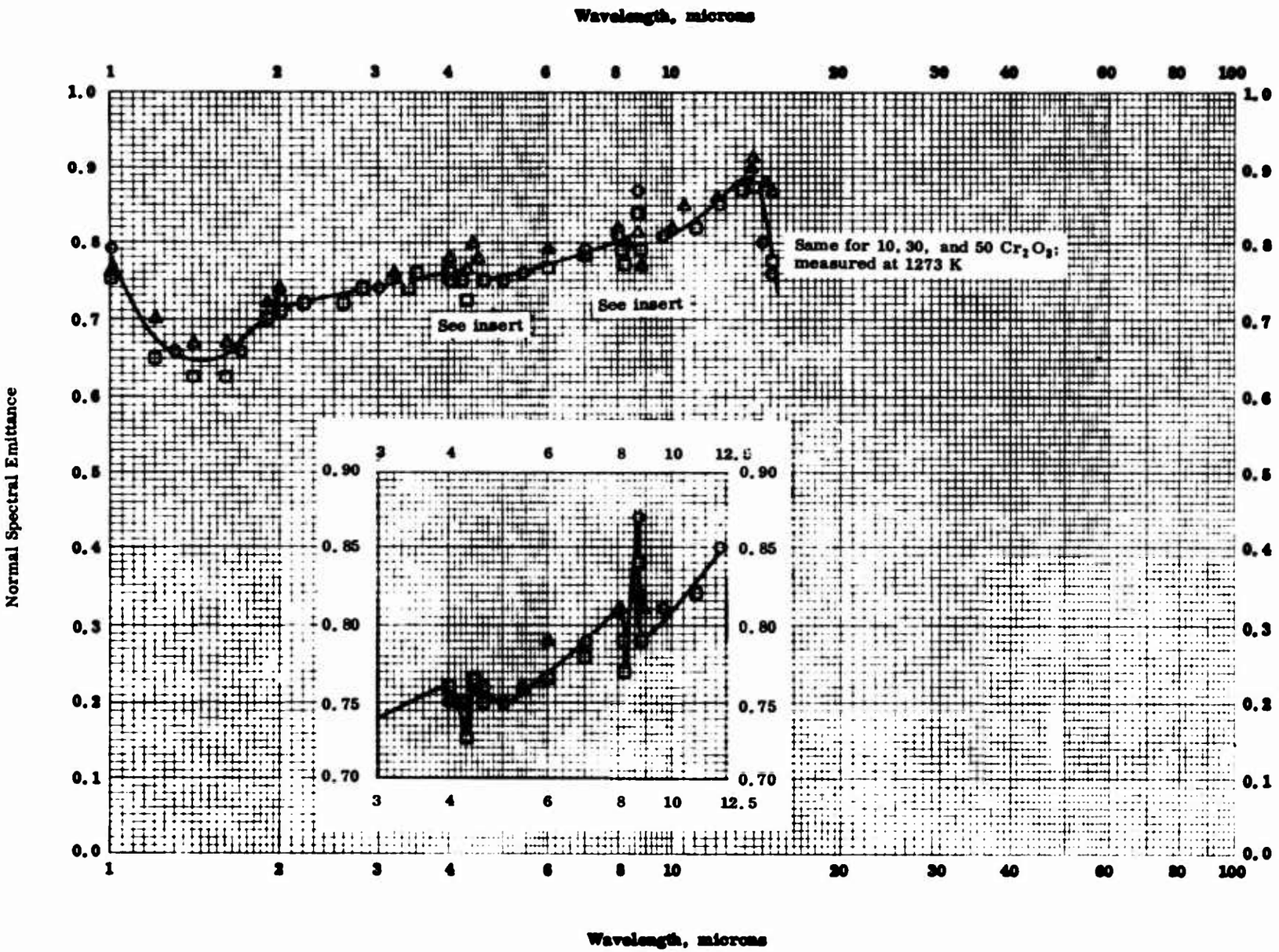


THERMAL LINEAR EXPANSION -- VANADIUM PENTOXIDE + TITANIUM DIOXIDE

THERMAL LINEAR EXPANSION -- VANADIUM PENTOXIDE + TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	60-42	296-973		51.72 V_2O_5 and 48.28 TiO_2; prepared from reagent grade V_2O_5 and Titanium Pigment Corporation's Titanox TG with 0.01> CaO, 0.1> WO_3, 0.008> Nb, 0.007> Sb_2O_3, 0.04> SiO_2, 0.006 Fe_2O_3, 0.001 V, 0.00005 Mn, 0.0005 Cu, 0.0004 Cr, and 0.001 - 0.002 Pb.	62.07 g V_2O_5 and 57.93 g TiO_2 ball-milled for 3 hrs, passed through a 4 mesh standard screen, mixed with 15 binder (40 g Carbowax 20 M, 20 cc of 2 Methocel solution and 40 cc H_2O), dried at 110 C for 1 hr, passed through a 16 mesh screen, pressed at 7000 psi into 1 in. disks about 1/4 in. thick, fired to 1200 C for 17 hrs, cooled to room temperature in less than 30 min, and crushed to minus 325 mesh; measured along a-axis by x-ray diffraction.
Δ	60-42	296-973		Same as above.	Same as above except measured along c-axis.

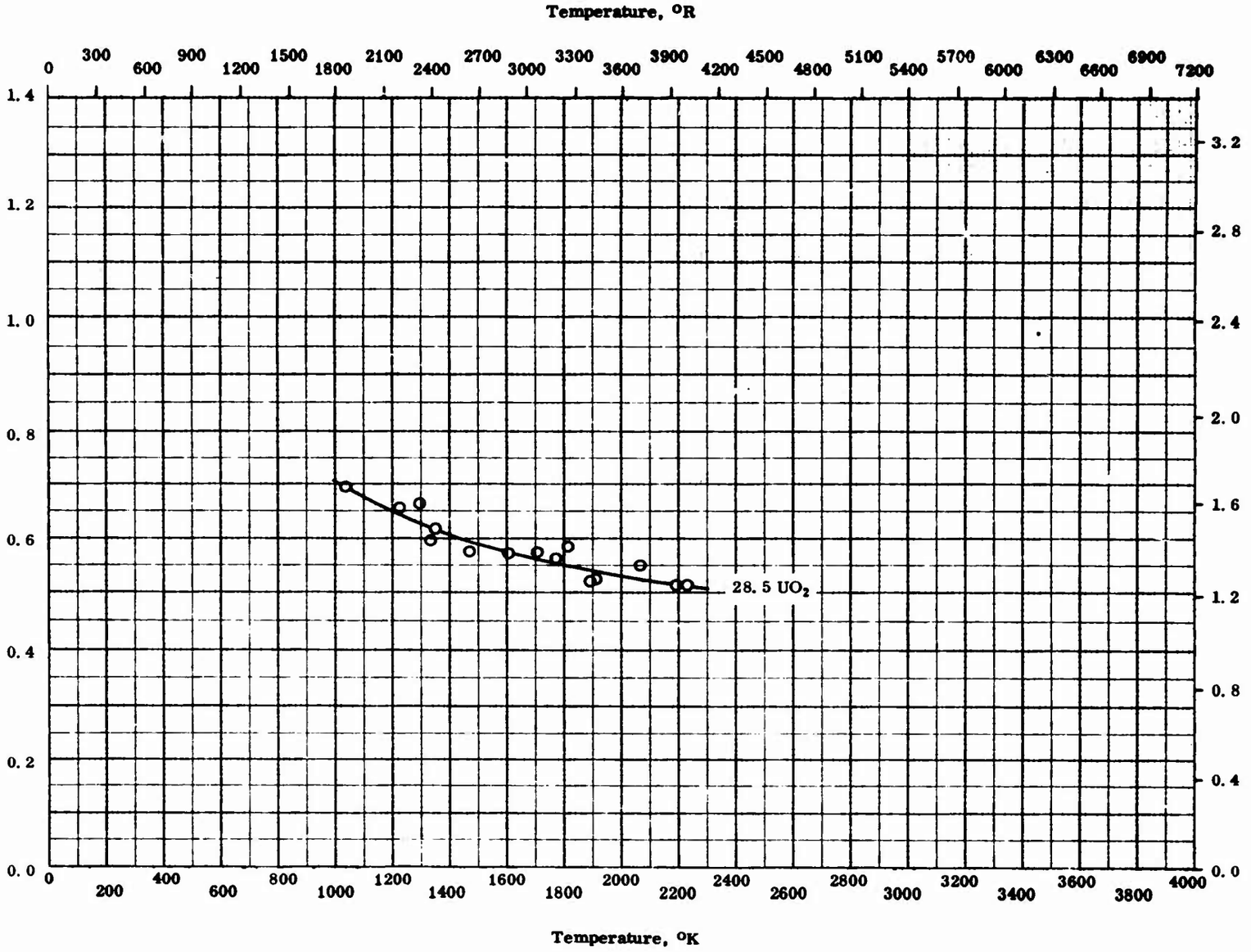


NORMAL SPECTRAL EMITTANCE -- YTTRIUM OXIDE + CHROMIUM SESQUIOXIDE

NORMAL SPECTRAL EMITTANCE -- YTTRIUM OXIDE + CHROMIUM SESQUIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
△	62-23	1273	1-15		90 Y_2O_3 and 10 Cr_2O_3, 0.05 in. thickness plate.	Sintered at 1973 K for 2 hrs; measured in air; data taken from a curve.
□	62-23	1273	1-15		70 Y_2O_3 and 30 Cr_2O_3, 0.053 in. thickness plate.	Same as above.
○	62-23	1273	1-15		50 Y_2O_3 and 50 Cr_2O_3, 0.046 in. thickness plate.	Same as above except sintered at 2123 K for 2 hrs.

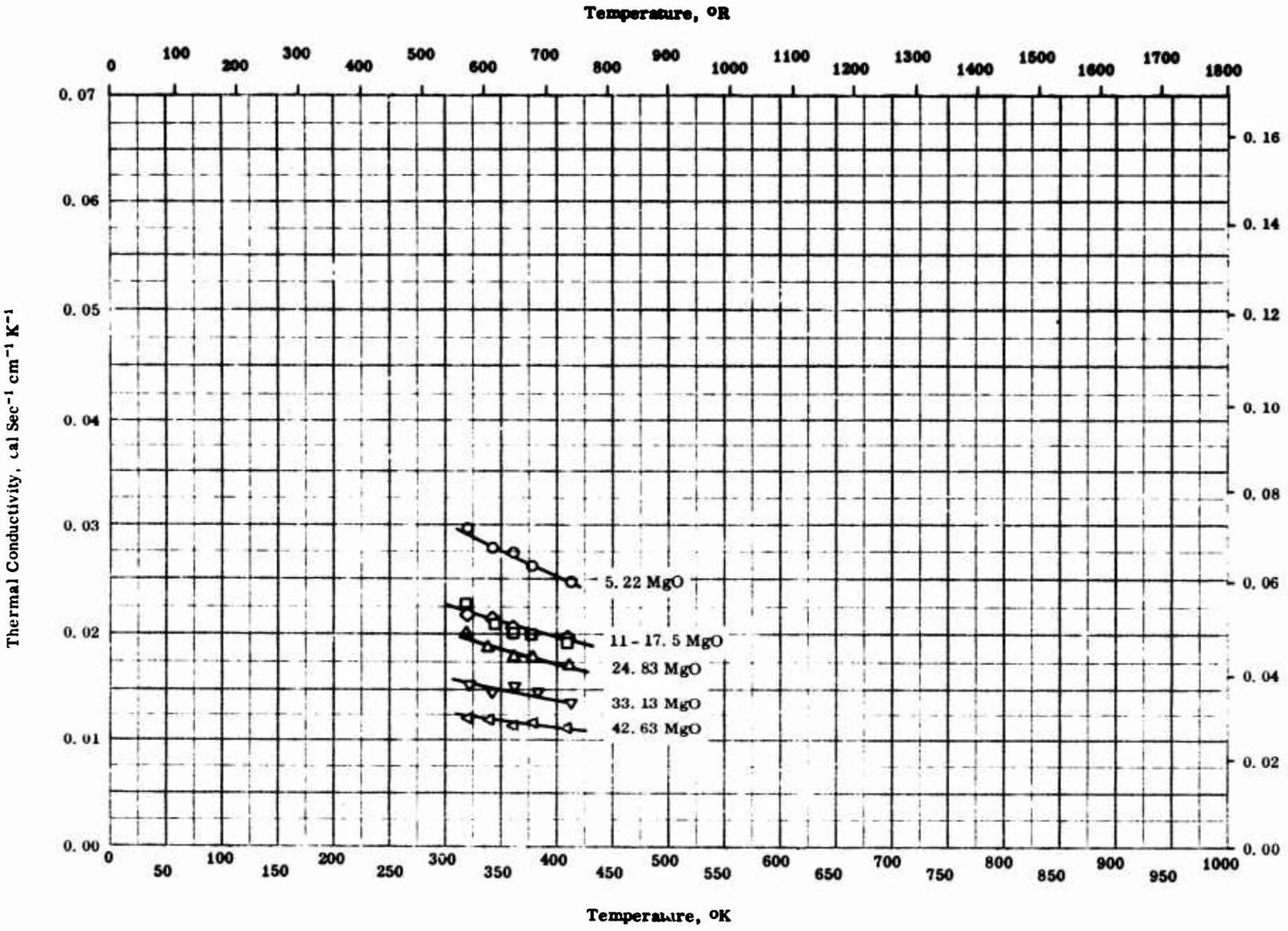


THERMAL CONDUCTIVITY -- YTTRIUM OXIDE + URANIUM DIOXIDE

THERMAL CONDUCTIVITY -- YTTRIUM OXIDE + URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	64-1	1038-2233		71.5 Y_2O_3 and 28.5 UO_2; a solid solution having corresponding composition of $UO_{2.2} \cdot 3Y_2O_3$; 99% of theoretical density.	

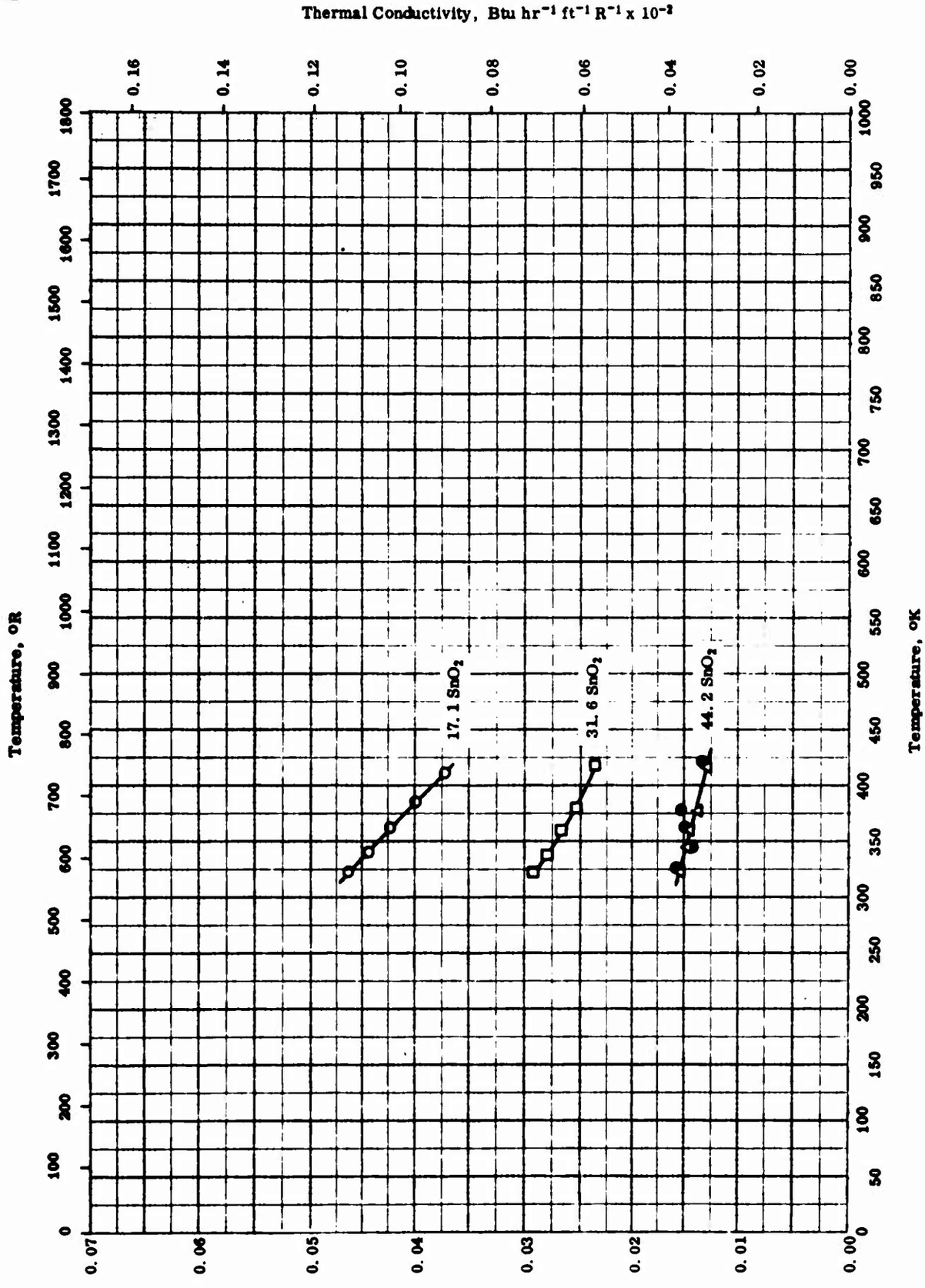


THERMAL CONDUCTIVITY -- ZINC OXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- ZINC OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-6	320-412		94.78 ZnO, 5.22 MgO; water absorption: 0.029%; density 326 lb ft^{-3}.	Corresponding to MgO: 9 ZnO; fired 2 hrs at 2500 F; tested in vacuum.
□	53-6	318-409		88.98 ZnO, 11.02 MgO; water absorption: 0.015%; density 313 lb ft^{-3}.	Corresponding to MgO: 4 ZnO; same as above.
◇	53-6	320-410		82.49 ZnO, 17.51 MgO; water absorption: 0.003%; density 312 lb ft^{-3}.	Corresponding to 3 MgO: 7 ZnO; fired 2 hrs at 2600 F; tested in vacuum.
△	53-6	318-410		75.17 ZnO, 24.83 MgO; water absorption: 0.010%; density 303 lb ft^{-3}.	Corresponding to 2 MgO: 3 ZnO; same as above.
▽	53-6	321-413		66.87 ZnO, 33.13 MgO; water absorption: 0.040%; density 304 lb ft^{-3}.	Corresponding to MgO: ZnO; same as above.
◁	53-6	291-409		57.37 ZnO, 42.63 MgO; water absorption: 0.006%; density 290 lb ft^{-3}.	Corresponding to 3 MgO: 2 ZnO; same as above.

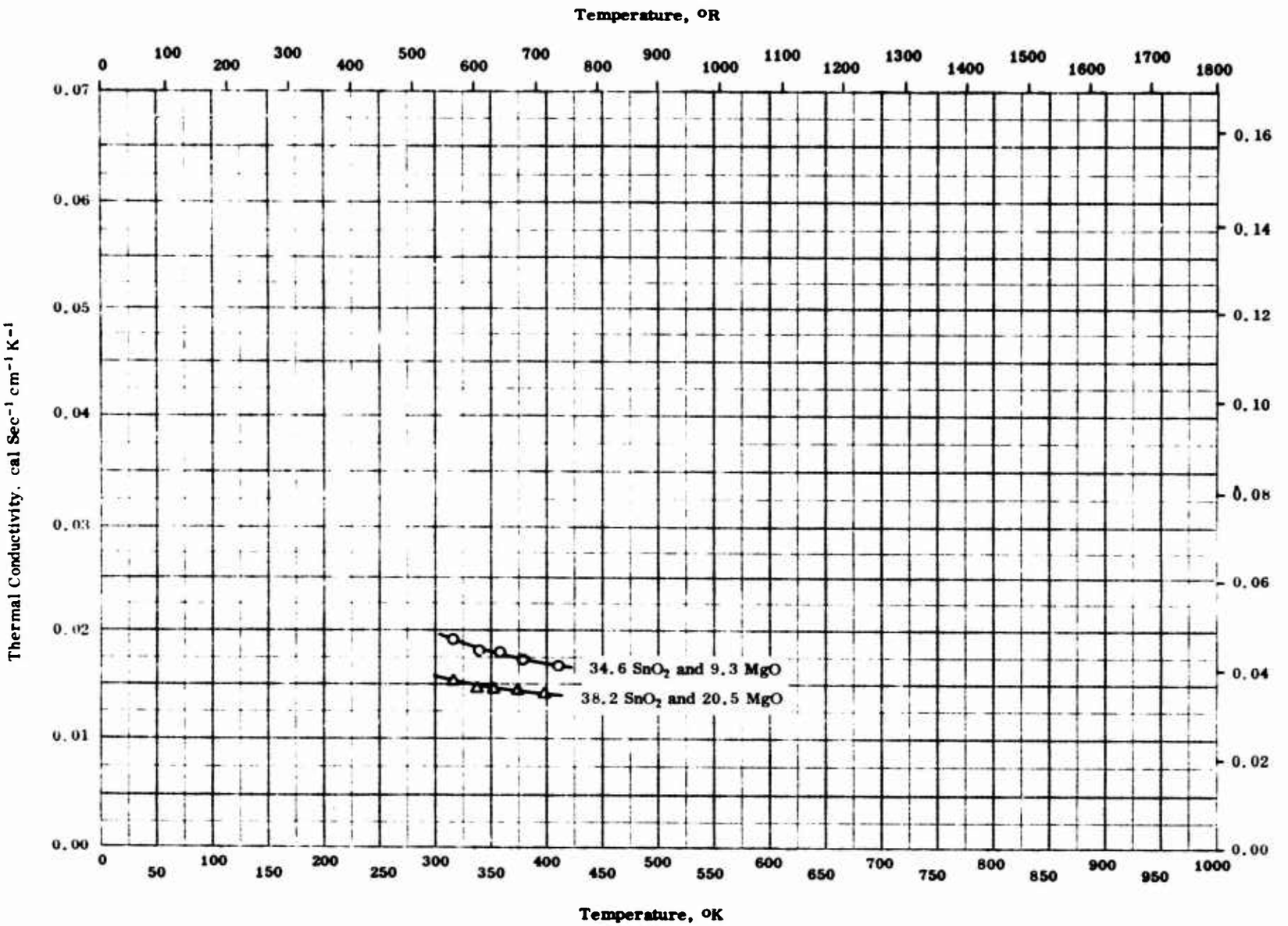


THERMAL CONDUCTIVITY -- ZINC OXIDE + TIN(IC) OXIDE

THERMAL CONDUCTIVITY -- ZINC OXIDE + TIN(IC) OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	53-6	323-411		82.9 ZnO and 17.1 SnO_2; density 5.73 g cm^{-3}.	Corresponding to SnO_2: 9 ZnO; prepared by calcining milled mixture of pure oxides at 2000 F and dry pressing at 15,000 psi; fired at 2500 F and soaked for 1 1/2 hrs.
□	53-6	323-418		68.4 ZnO and 31.6 SnO_2; density 5.90 g cm^{-3}.	Corresponding to SnO_2: 4 ZnO; same as above.
△	53-6	322-417		55.8 ZnO and 44.2 SnO_2; density 5.67 g cm^{-3} and water absorption 1.062%.	Corresponding to 3 SnO_2: 7ZnO; same as above except heat-soaked for 1 hr.
●	53-6	326-421		Same as above except water absorption 1.57% and density 5.62 g cm^{-3}.	Same as above.

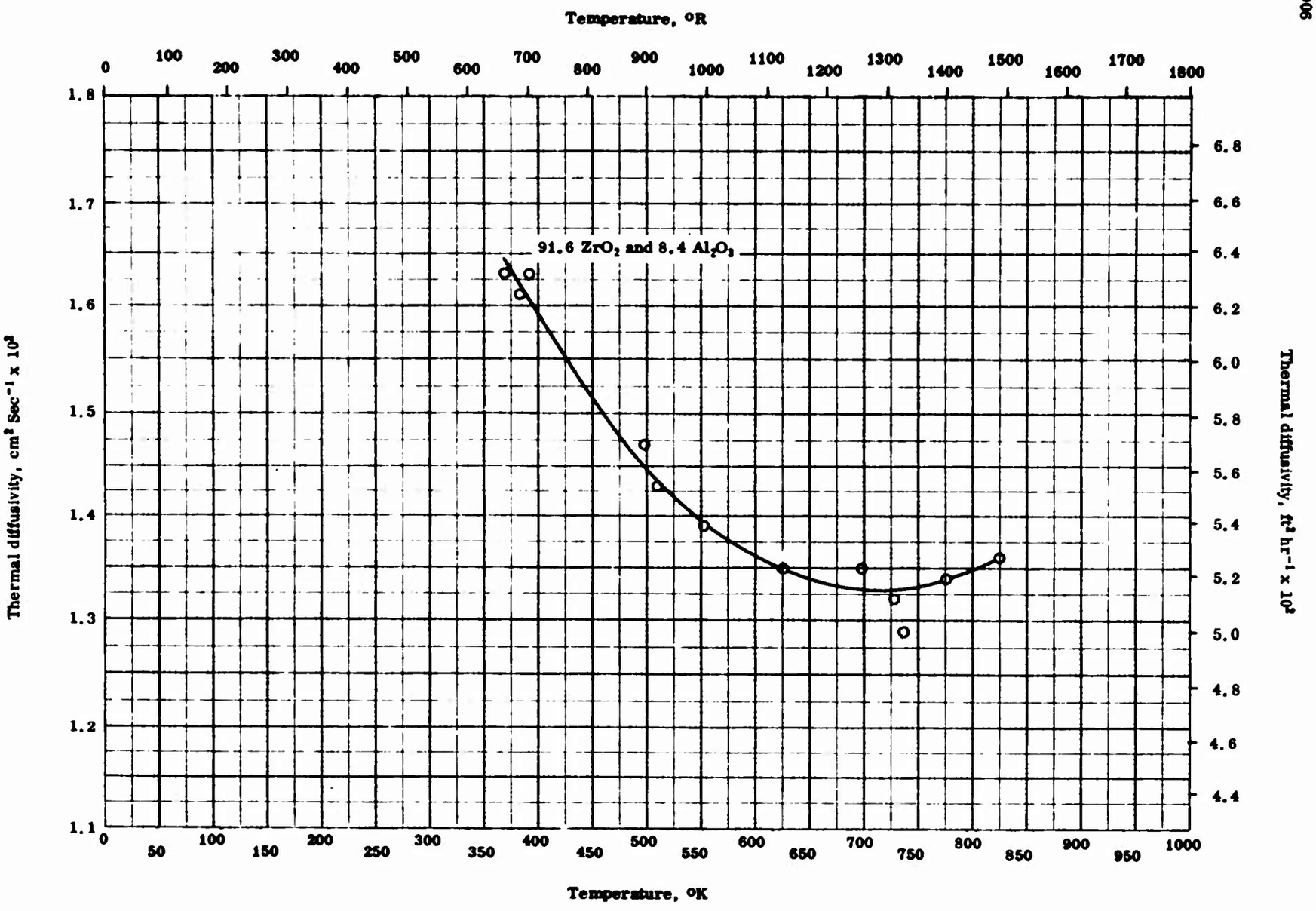


THERMAL CONDUCTIVITY -- ZINC OXIDE + TIN (IC) OXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- ZINC OXIDE + TIN (IC) OXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	53-6	316-410		56.1 ZnO, 34.6 SnO_2, and 9.3 MgO; density 4.80 g cm^{-3} and water absorption 0.082%.	Corresponding to MgO : SnO_2 : 3 ZnO; calcined milled and dried pure oxides at 2000 F, dry-pressed at 15000 psi, and fired at 2600 F and heat-soaked for 1 1/2 hrs.
Δ	53-6	316-398		41.3 ZnO, 38.2 SnO_2, 20.5 MgO; density 4.86 g cm^{-3} and water absorption 0.006%.	Corresponding to 2 MgO : SnO_2 : 2 ZnO; same as above.

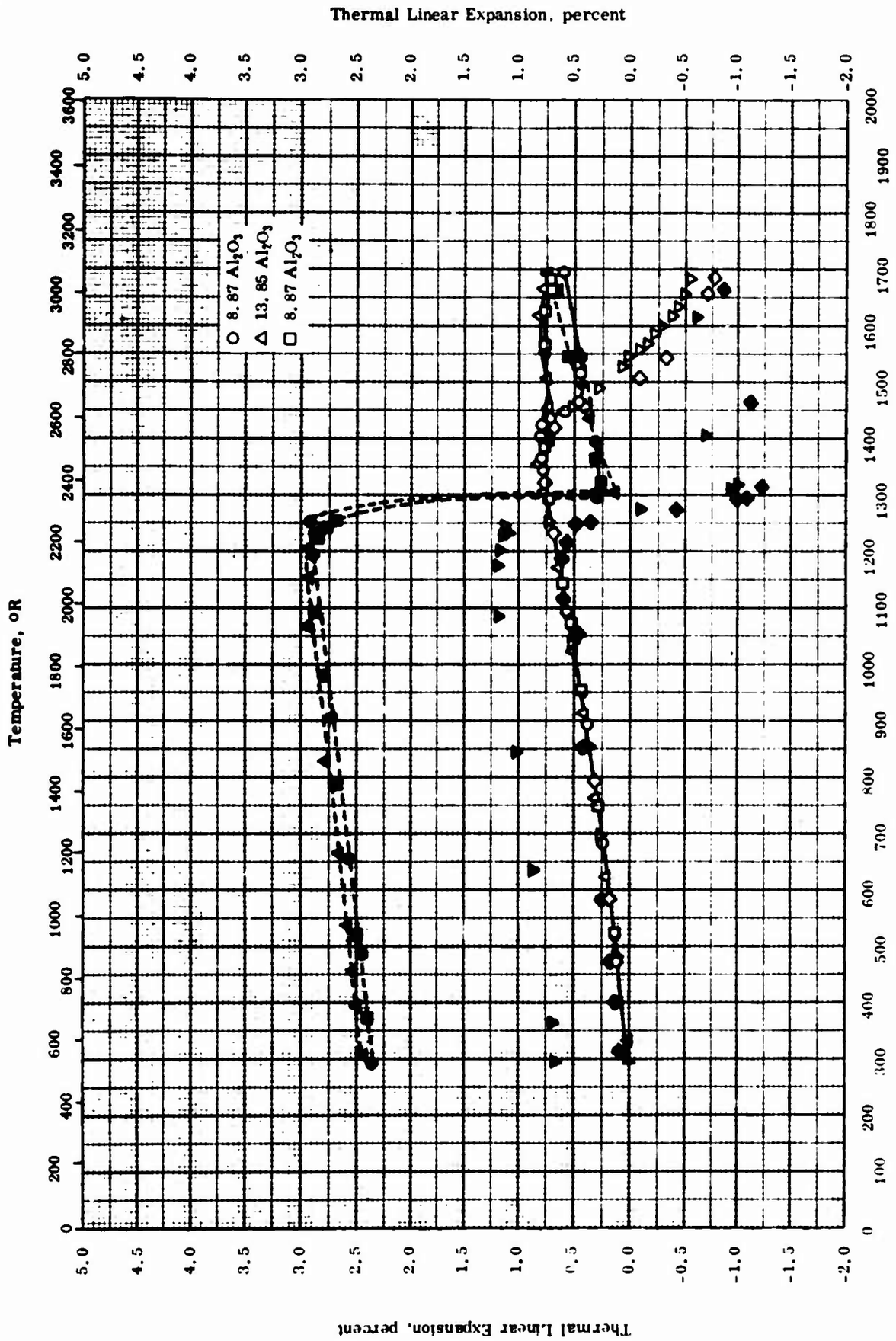


THERMAL DIFFUSIVITY -- ZIRCONIUM DIOXIDE +ALUMINUM OXIDE

THERMAL DIFFUSIVITY -- ZIRCONIUM DIOXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-3	368-826		91.58 ZrO_2 and 8.42 Al_2O_3; corresponding to 10 mole % Al_2O_3.	Zirconia stabilized; sintered at 1850-60C, soaked for 2 hrs at that temperature in Rommy furnace and cooled with the furnace; all surface ground.

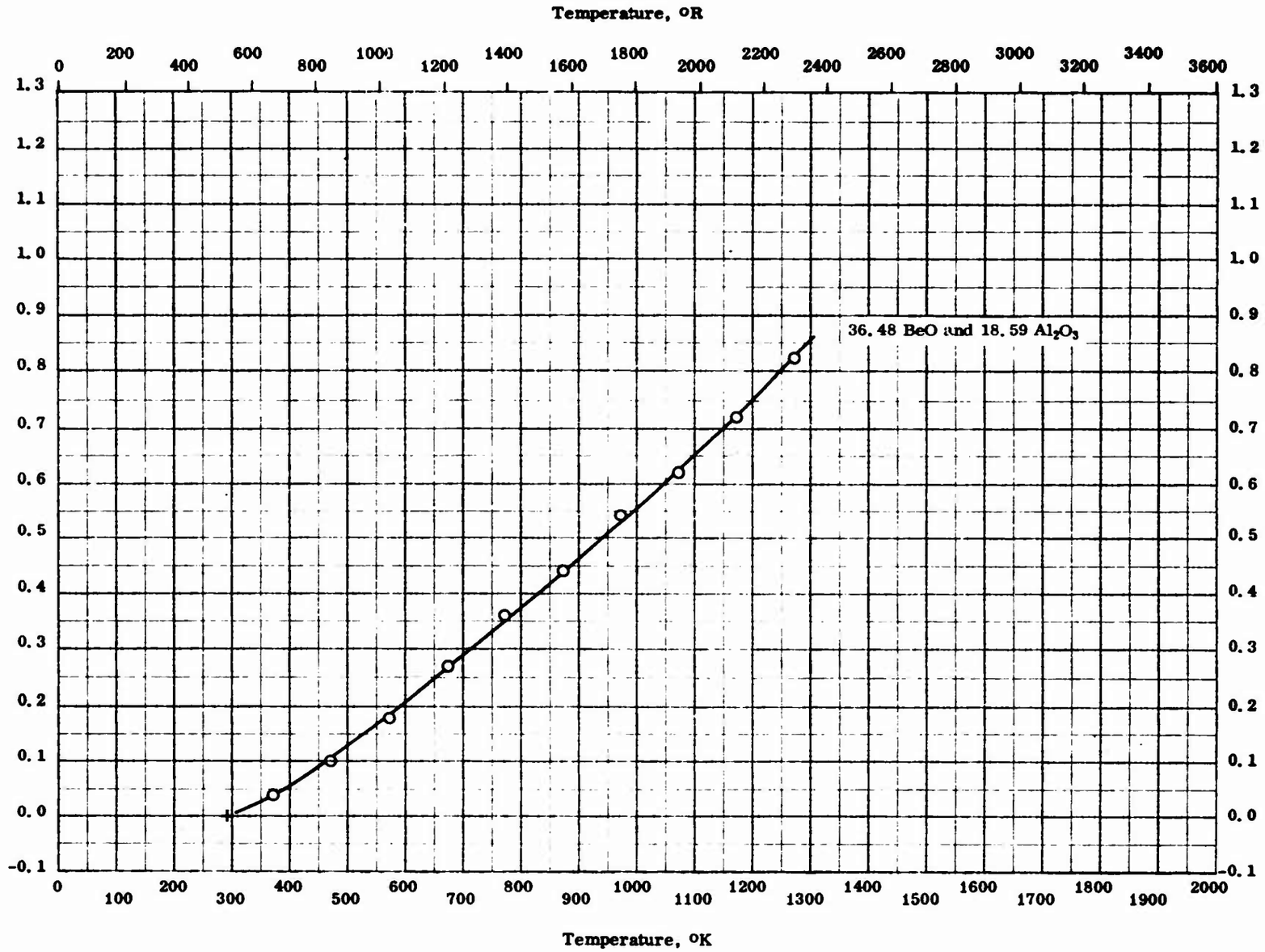


THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + ALUMINUM OXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	63-3	293-1698		91.13 ZrO_2 and 8.87 Al_2O_3 from Aeronautical Research Laboratories, Wright-Patterson AF Base; dimensions 3/4 in. long by 3/8 in.^{2}.	Cold pressed, sintered at 1850 - 1860 C, soaked 2 hrs at temperature, cooled, and cut into bars; measured with heating rate of approx 2.5 C min^{-1} in "stagnant" oxidizing atm; monoclinic to tetragonal inversion occurred in 1100 - 1200 C range.
●	63-3	293-1543		Same as above.	Cooling cycle for above sample: tetragonal to monoclinic inversion occurred in 950 - 1025 C range.
△	63-3	293-1690		86.15 ZrO_2 and 13.85 Al_2O_3; same as above.	Same as heating cycle for above sample.
▲	63-3	307-1661		Same as above.	Cooling cycle for above sample; tetragonal to monoclinic inversion occurred in 950 - 1025 C range.
□	63-3	279-1682		91.13 ZrO_2 and 8.87 Al_2O_3; same as above. [Author's design: Run 1]	Same as heating cycle for above sample except monoclinic to tetragonal inversion occurred at about 1100 C.
■	63-3	377-1547		Same as above.	Cooling cycle for above sample; tetragonal to monoclinic inversion occurred in 900 - 1050 C range.
▽	63-3	317-1681		Same as above. [Author's design: Run 2]	Second heating cycle for above sample.
▼	63-3	299-1617		Same as above.	Second cooling cycle for above sample.
◇	63-3	299-1682		Same as above. [Author's design: Run 3]	Third heating cycle for above sample.
◆	63-3	313-1667		Same as above.	Third cooling cycle for above sample; overall change in length after three cycles 2.93 %.

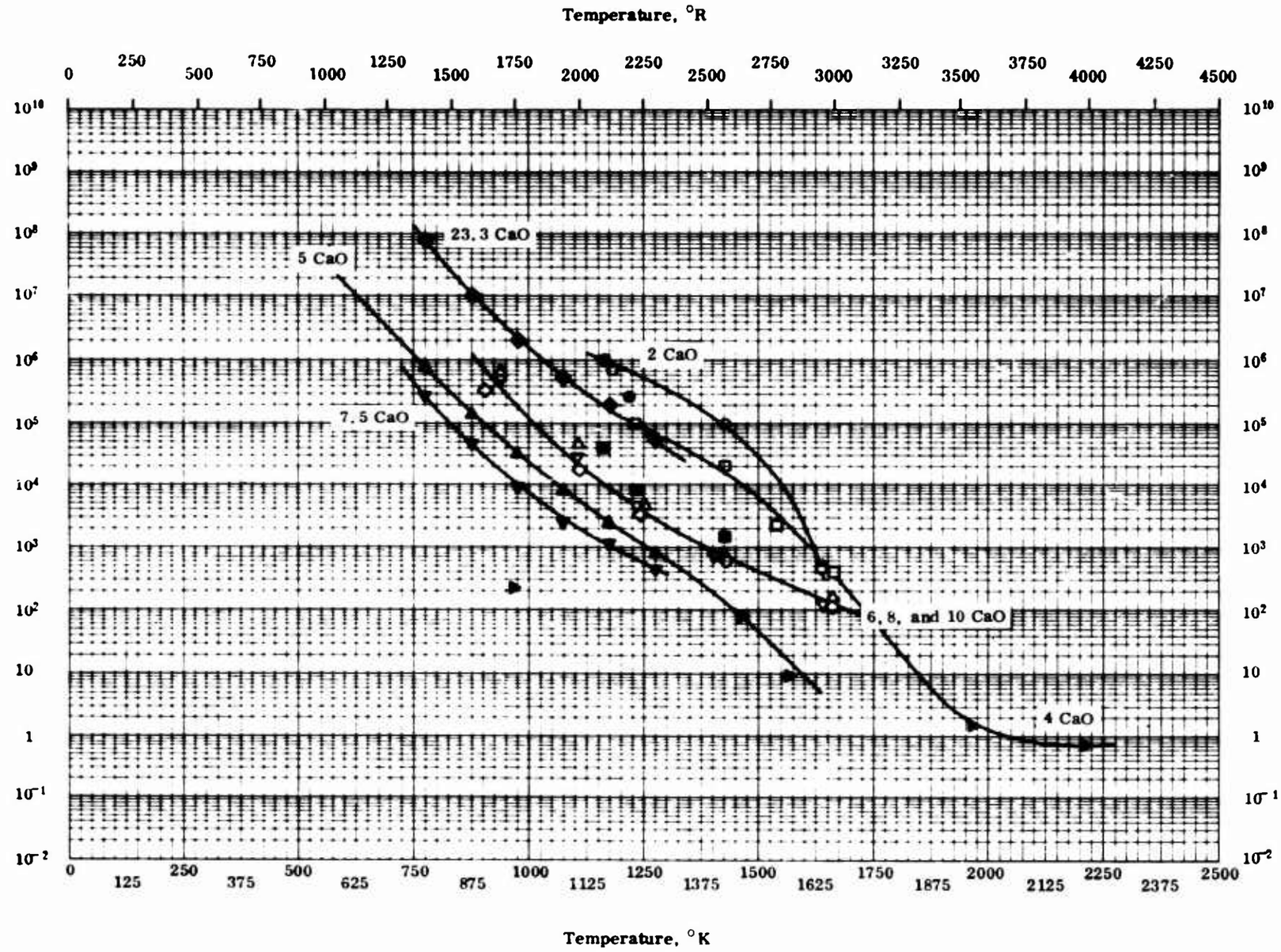


THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE +BERYLLIUM OXIDE + ALUMINUM OXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + BERYLLIUM OXIDE + ALUMINUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	46-4	293-1273		44.92 ZrO_2, 36.48 BeO, and 18.59 Al_2O_3 (corresponds to 8 BeO · Al_2O_3 · 2 ZrO_2); prepared from 99.7 pure BeO, 99+ pure Al_2O_3, and c.p. ZrO_2 (calcined).	



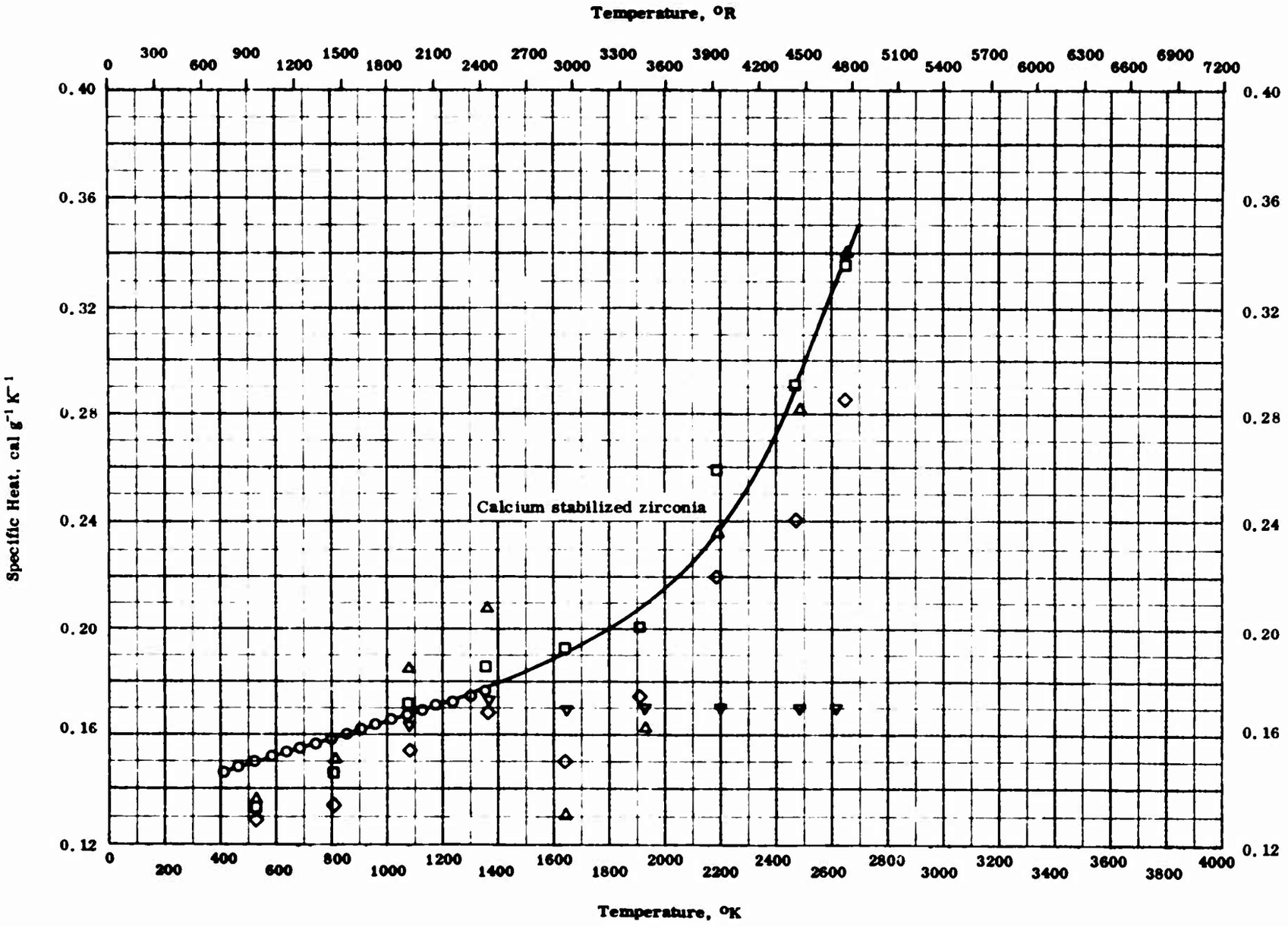
ELECTRICAL RESISTIVITY -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE

TPRC

ELECTRICAL RESISTIVITY -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	56-11	1143-1640		97.61 ZrO_2, 2 CaO, and 0.20 SiO_2; made from ZrO_2 with 0.20 SiO_2, trace Al_2O_3, Fe_2O_3, TiO_2; density 362 lb ft^{-3}.	Heating.
●	56-11	1143-1640		Same as above.	Cooling.
□	56-11	1163-1667		95.62 ZrO_2, 4 CaO, and 0.19 SiO_2.	Same as above, heating.
■	56-11	1163-1667		Same as above.	Cooling.
△	56-11	943-1667		93.62 ZrO_2, 6 CaO, and 0.19 SiO_2.	Same as above, but average of heating and cooling data.
◇	56-11	909-1667		91.63 ZrO_2, 8 CaO, and 0.18 SiO_2.	Same as above.
▽	56-11	935-1667		89.64 ZrO_2, 10 CaO, and 0.18 SiO_2.	Same as above.
▶	52-5	717-2217		94 - 95 ZrO_2, 4 - 5% CaO, 0.22 - 1.0 TiO_2, 0.14 - 0.75 SiO_2, and 0.2 - 0.7 Fe_2O_3.	
▲	60-20	773-1273	1.0	95.19 ZrO_2 and 4.81 CaO.	Corresponding to 9 ZrO_2: 1 CaO; prepared by roasting the oxides at 1200 C for hrs, milled to 200 mesh, molded to form tablets with dimensions 1.0 x 1.0 x 0.2 - 0.4 cm under 4000 kg - cm^{-2} pressure; sintered at 1500 ± 20 and holding of one hour at the maximum temperature.
▼	60-20	773-1273	1.0	92.57 ZrO_2 and 7.43 CaO.	Corresponding to 8.5 ZrO_2: 1.5 CaO; same as above.
◆	60-20	773-1273	1.0	76.72 ZrO_2 and 23.28 CaO.	Corresponding to 6.0 ZrO_2: 4.0 CaO; same as above.

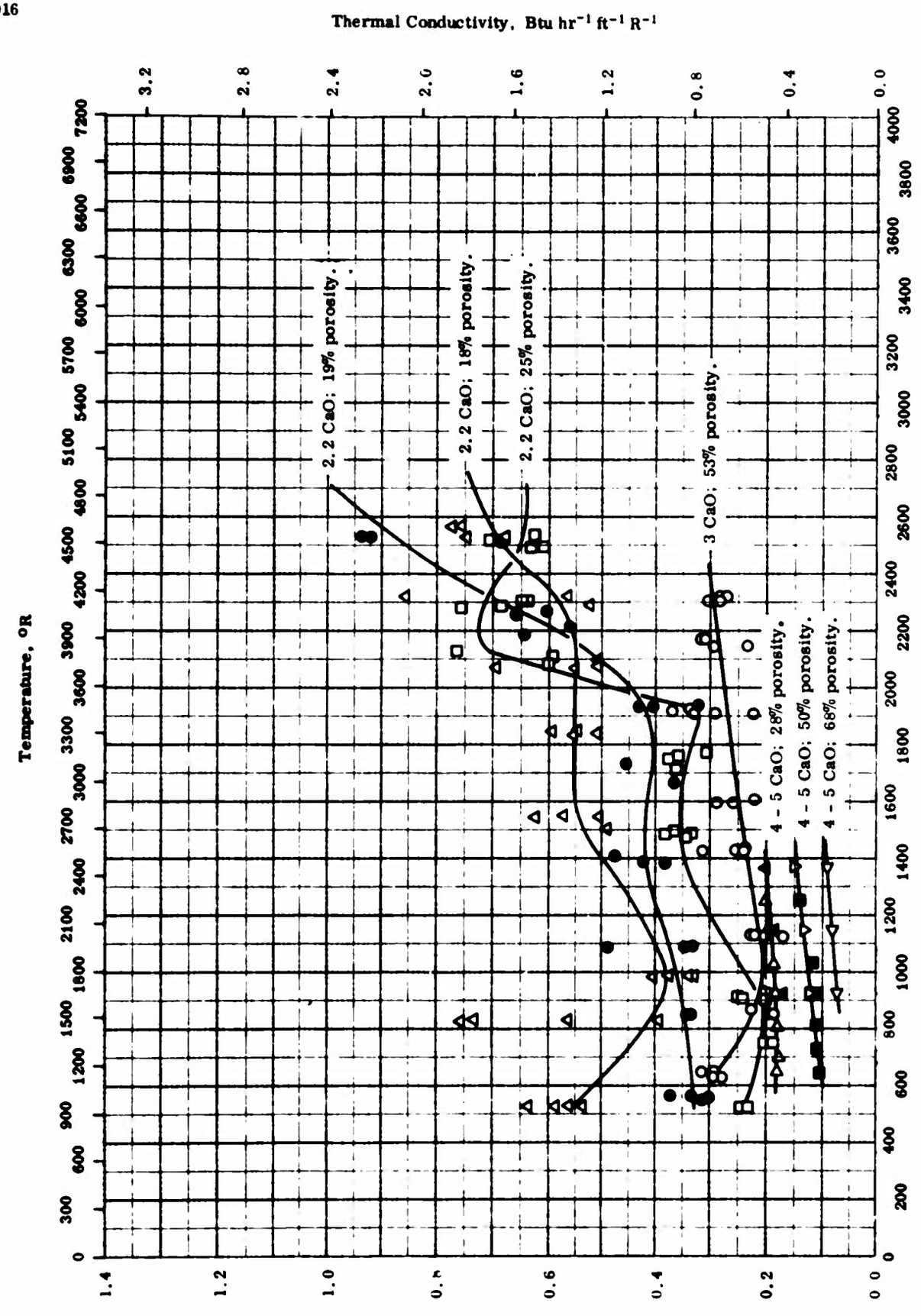


SPECIFIC HEAT -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE

SPECIFIC HEAT -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-17	422-1366	5.0	Calcium stabilized zirconia; 91.2 ZrO_2, 5.25 CaO, 1.84 SiO_2, 0.62 MgO, 0.49 Al_2O_3, 0.29 TiO_2, and 0.20 FeO; density 3.20 lb ft^{-3}.	Sample made by spraying powdered ZrO_2 using powder gun with 90 ft^3 hr^{-1} nitrogen, 10 ft^3 hr^{-1} hydrogen plasma gas and 10 ft^3 hr^{-1} nitrogen as carrier gas.
□	62-15	533-2650	5.0	Stabilized zirconia; fine grain; 96.00 ZrO_2, 2.99 CaO, 0.26 $CaSO_4$, 0.21 MgO_2, 0.34 SiO_2, 0.14 SO_4; density 335.2 lb ft^{-3}; fine grain; porosity 0.43%. [Author's design. Zirconia 1.]	Fabricated into right circular cylinders by extroding at < 1000 lb in^{-2} pressure.
△	62-15	533-2656	5.0	Same as above. [Author's design. Zirconia 2.]	Same as above.
◇	62-15	533-2640	5.0	Same as above. [Author's design. Zirconia 3.]	Same as above.
▽	62-15	531-2611	5.0	Stabilized zirconia; 30% fines and 70% grog (fines composition same as above and composition of grog: 97.60 ZrO_2, 1.82 CaO, 0.27 $CaSO_4$, 0.12 SiO_2, 0.15 SO_4); density 290.3 lb ft^{-3} and porosity 18.54%.	

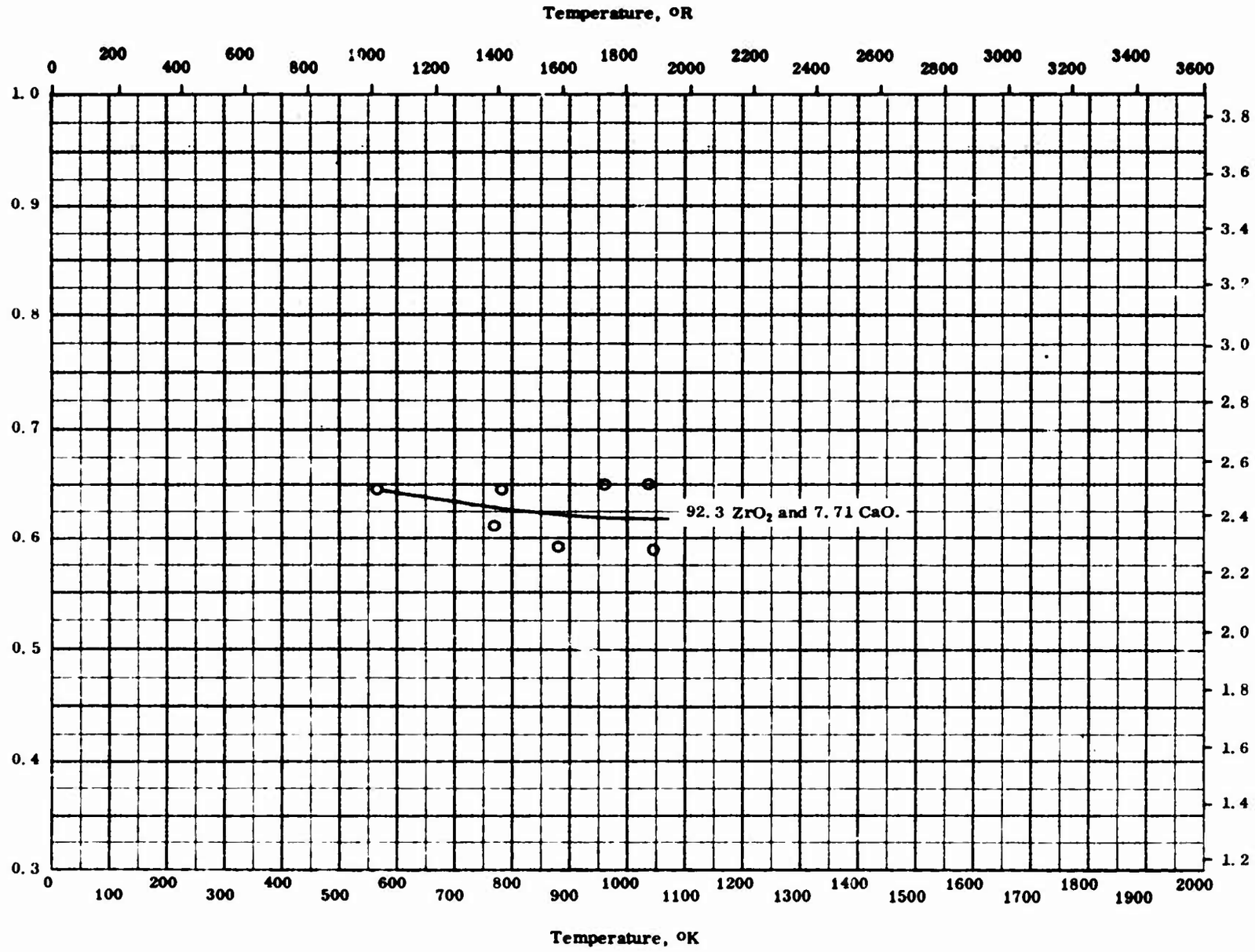


THERMAL CONDUCTIVITY -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE

THERMAL CONDUCTIVITY -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
▲	52-5	922-1367		94-95 ZrO_2, 4-5 CaO, 0.14 - 0.75 SiO_2, 0.2 - 0.7 Fe_2O_3, 0.22 - 1.0 TiO_2; porosity 28%.	Stabilized.
▽	52-5	922-1367		Same as above; porosity 51%.	Stabilized.
◁	52-5	922-1367		Same as above; porosity 68%.	Stabilized.
▷	49-1	645-1311		98^+ ZrO_2 + CaO; stabilized zirconia mix No. 148-A-dense; density 250 lb ft^{-3}; total porosity 28%; apparent porosity 26%.	Made from 14 mesh grain or finer; fired at 3230 F.
■	49-1	645-1311		98^+ ZrO_2 + CaO; stabilized zirconia mix No. 187; density 175 lb ft^{-3}; total porosity 50%; apparent porosity 44%.	Made from 8 mesh grain or finer; fired at 3230 F.
○	62-5	626-2303		96 ZrO_2, 2.99 CaO, 0.34 SiO_2, 0.26 $CaSO_4$, 0.21 MgO, and 0.18 SO_4; fine grain with density 0.203 lb in^{-3} and porosity 53% .	Sintered, stabilized, and molded.
△	62-5	526-2565		97.12 ZrO_2, 2.17 CaO, 0.267 $CaSO_4$, 0.186 SiO_2, 0.173 SO_4, and 0.063 MgO; coarse grain with density 0.168 lb in^{-3} and porosity 18.58%.	Formulated by 30% fine ZrO_2 (with 2.99 CaO, 0.34 SiO_2, 0.26 $CaSO_4$, 0.21 MgO, and 0.18 SO_4) and 70% grog ZrO_2 (with 1.82 CaO, 0.27 $CaSO_4$, 0.17 SO_4, and 0.12 SiO_2); sintered, stabilized, and molded.
□	62-5	525-2540		Same as above except porosity 25%.	Same as above.
●	62-5	551-2537		Same as above except density 0.165 lb in^{-3} and porosity 19.4%.	Same as above; extruded.



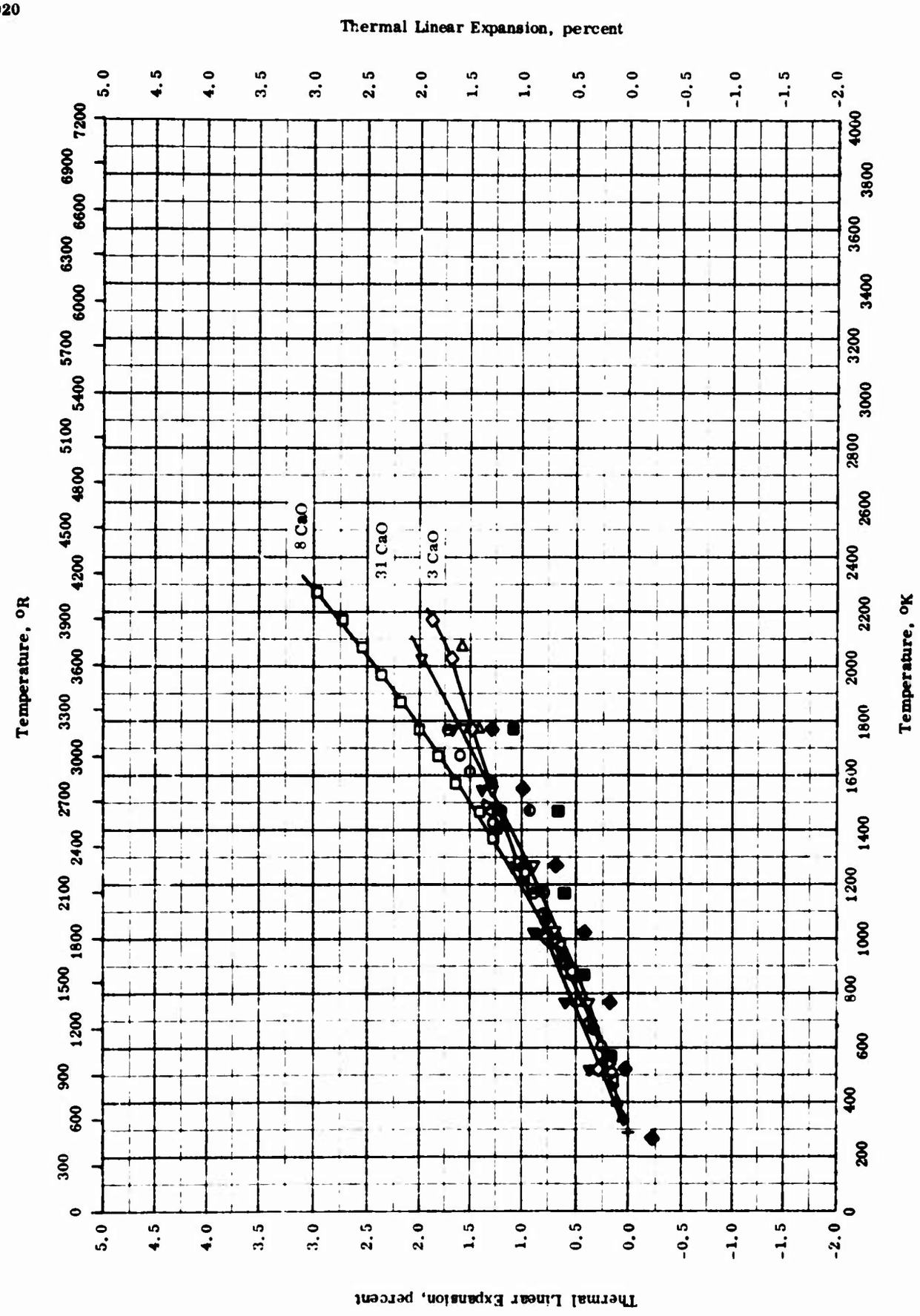
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THERMAL DIFFUSIVITY -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE

THERMAL DIFFUSIVITY -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-3	563-1043		92.29 ZrO_2 and 7.71 CaO; corresponding to 15.5 mole % of CaO.	Zirconia stabilized; sintered at 1850-60C, soak for 2 hrs at that temperature in Rummy furnace and cooled with it; all surface ground.



THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	63-3	299-1677		92.29 ZrO_2 and 7.71 CaO from Aeronautical Research Laboratories, Wright-Patterson AF Base; dimensions 3/4 in. long by 3/8 in.[2] [Author's design: Run 1]	Cold pressed, sintered at 1850 - 1860 C, soaked 2 hrs at temperature, cooled, and cut into bars; measured with heating rate of approx 2.5 C min^{-1} in "stagnant" oxidizing atm; author states that presence of CaO apparently stabilizes ZrO_2 in cubic form.
△	63-3	299-1473		Same as above. [Author's design: Run 2]	Second heating cycle for above sample.
▲	63-3	559-1411		Same as above.	Cooling cycle for above sample.
▽	63-3	299-1493		Same as above. [Author's design: Run 3]	Third heating cycle for above sample.
▼	63-3	479-1461		Same as above.	Cooling cycle for above sample.
□	63-36	293-2273		92.0 ZrO_2 and 8 CaO; prepared from finely milled specially pure zirconia (99.5 ZrO_2); dimensions 4 by 4 by 20 mm; bulk density 5.38 g cm^{-3}; apparent porosity 4.8%. [Author's design: Body 6]	ZrO_2 stabilized with CaO, pressed at 500 kg cm^{-2}, and fired at 1730 C; rate of temperature rise 5 - 8 C min^{-1}; measured in vacuum furnace; authors reported average coefficients.
◇	49-9	273-2173		97 ZrO_2 and 3 CaO.	Melted in solar furnace.
◆	49-9	273-1773		Same as above.	Cooling cycle for above sample.
▷	49-9	273-2073		97 ZrO_2 and 3 CaO.	Melted in electric arc, broken up, consolidated and baked at 2200 C.
◁	49-9	273-2023		69 ZrO_2 and 31 CaO.	Heating cycle.
◀	49-9	273-1773		Same as above.	Cooling cycle for above sample.

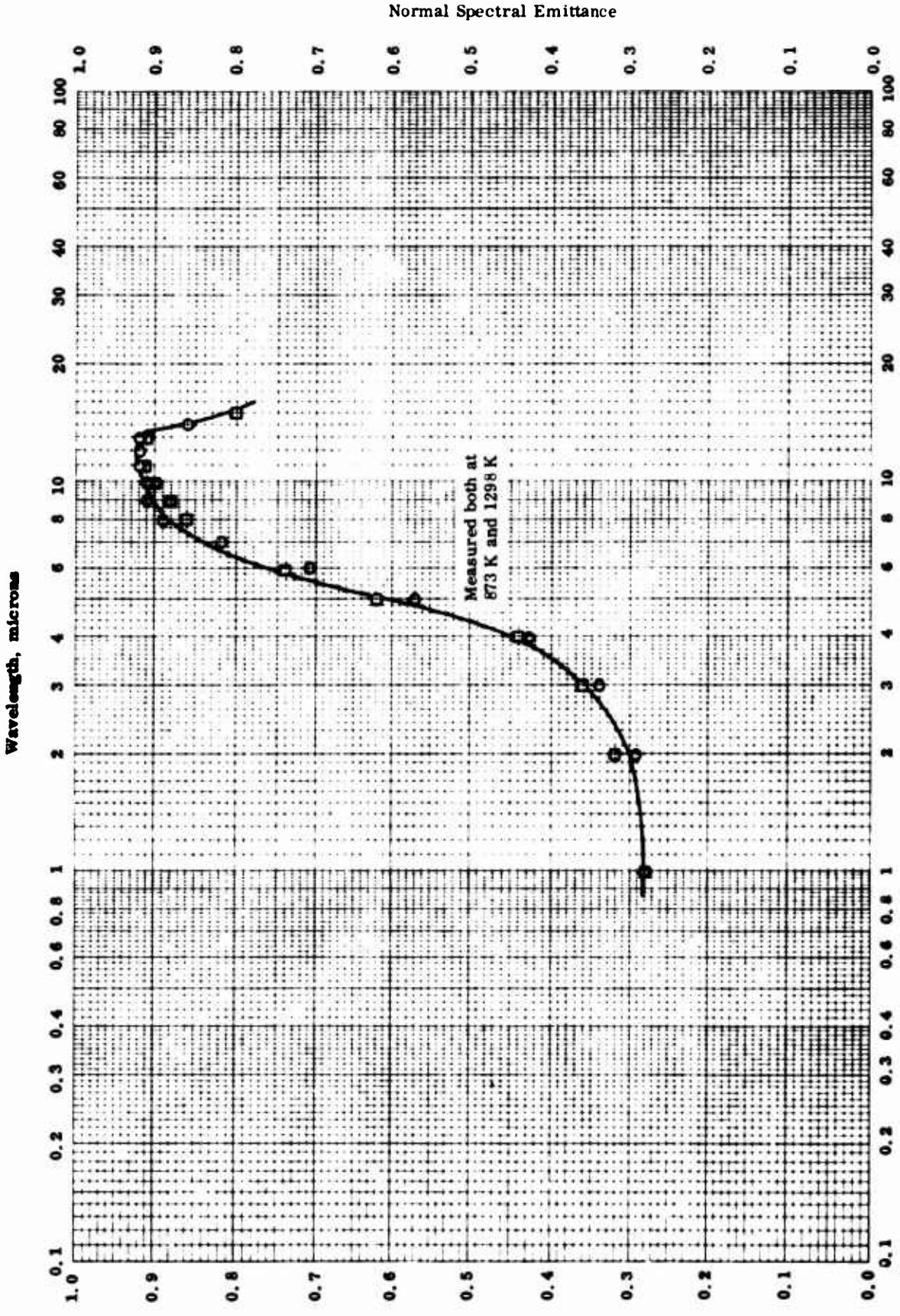
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THERMAL LINEAR EXPANSION -- ZIRCONIUM OXIDE + CALCIUM OXIDE (Continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
●	52-21	295-1573		ZrO_2 with < 1 impurities; stabilized with 4 CaO.	Slip cast, dried, fired at 1150 C, machined, and matured 3 hrs at 1830 C; tested at 4 C min^{-1} rise.
◒	55-37	273-1097		92.29 ZrO_2 and 7.71 CaO; cubic phase only; prepared from c.p. raw materials.	Tested in He atm by x-ray diffraction.
■	56-28	573-1773		Coarse fused, stabilized.	Probably calcia stabilized.
◓	56-28	573-1773		Same as above.	Same as above.
◑	56-28	573-1773		100% cubic; fused.	Same as above.
▶	50-9	300-867		Stabilized; 0.16 combined C and 0.01 > free C; apparent density 362 lb ft^{-3}.	Probably calcia stabilized; hot pressed in graphite mold; tested at 4 C min^{-1} rise.

NORMAL SPECTRAL EMITTANCE -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE



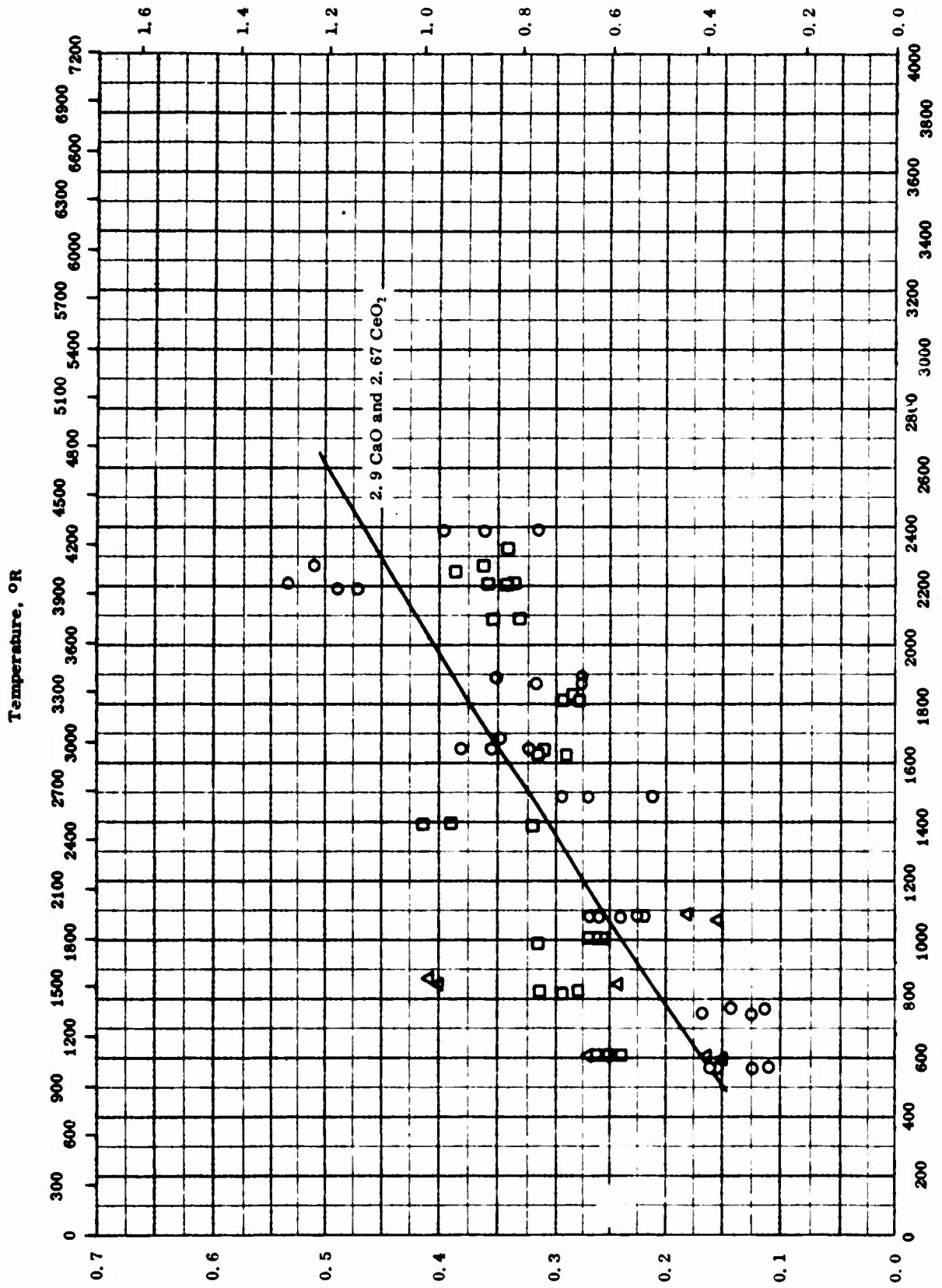
Normal Spectral Emittance

TPRC

NORMAL SPECTRAL EMITTANCE -- ZIRCONIUM DIOXIDE +CALCIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. °K	Wavelength Range, μ	Rept. Error %	Sample Specifications	Remarks
○	60-30	873	2-14	± 4	92 ZrO_2 and 4.5 CaO.	Ultrasonically machined; measured in air.
□	60-30	1298	1-15	± 4	Same as above.	Same as above.

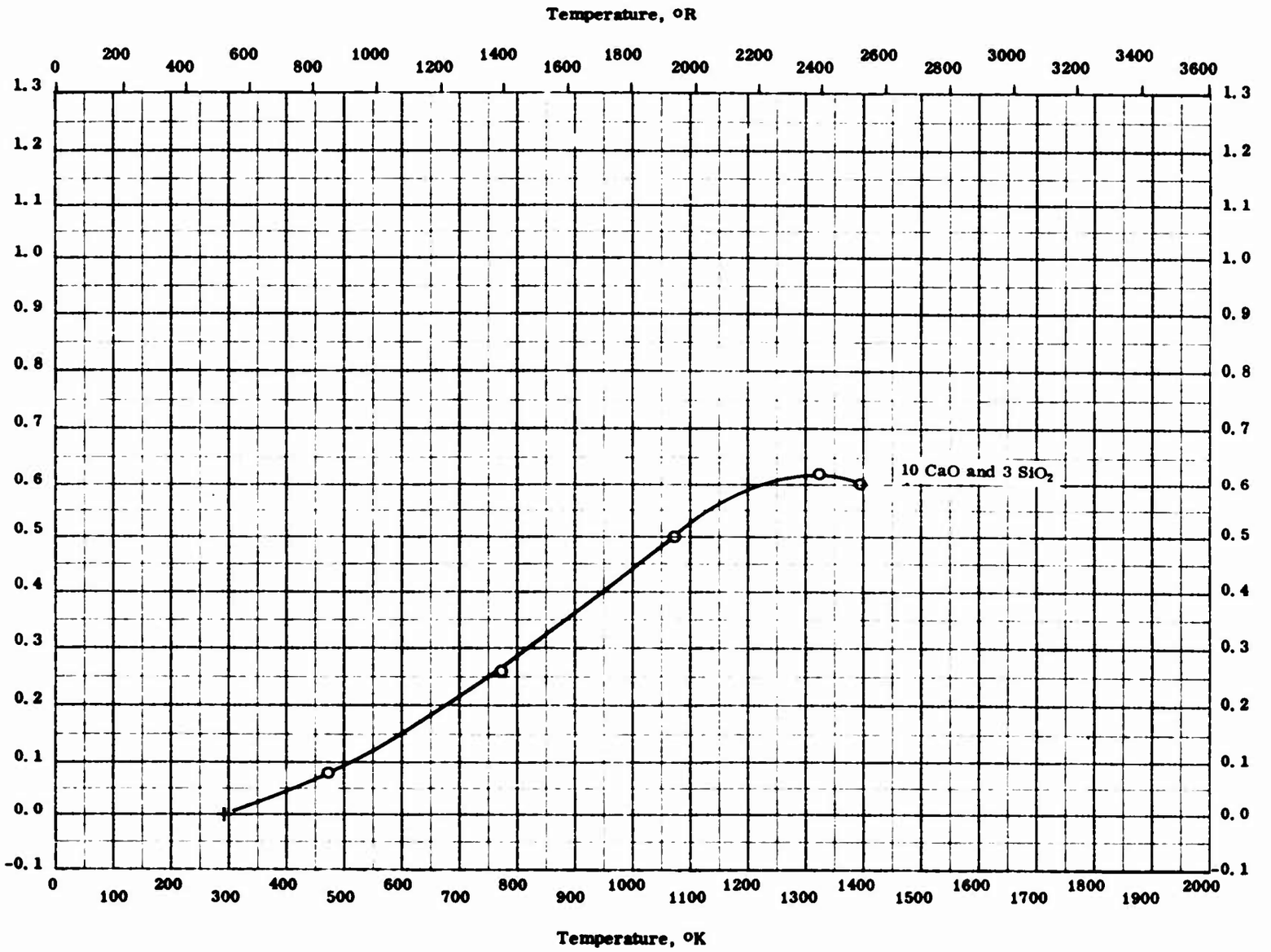


THERMAL CONDUCTIVITY -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE + CERIUM DIOXIDE

THERMAL CONDUCTIVITY -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE + CERIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
△	62-5	600-1088		93.216 ZrO_2, 2.903 CaO, 2.67 CeO_2, 0.33 SiO_2, 0.252 $CaSO_4$, 0.204 MgO, 0.175 other sulfates, and 0.22 other oxides; coarse grain; density 0.150 lb in^{-3} and porosity 31.0%.	Stabilized zirconia; molded.
○	62-5	568-2387		Same as above.	Same as above.
□	62-5	607-2336		Same as above.	Same as above.

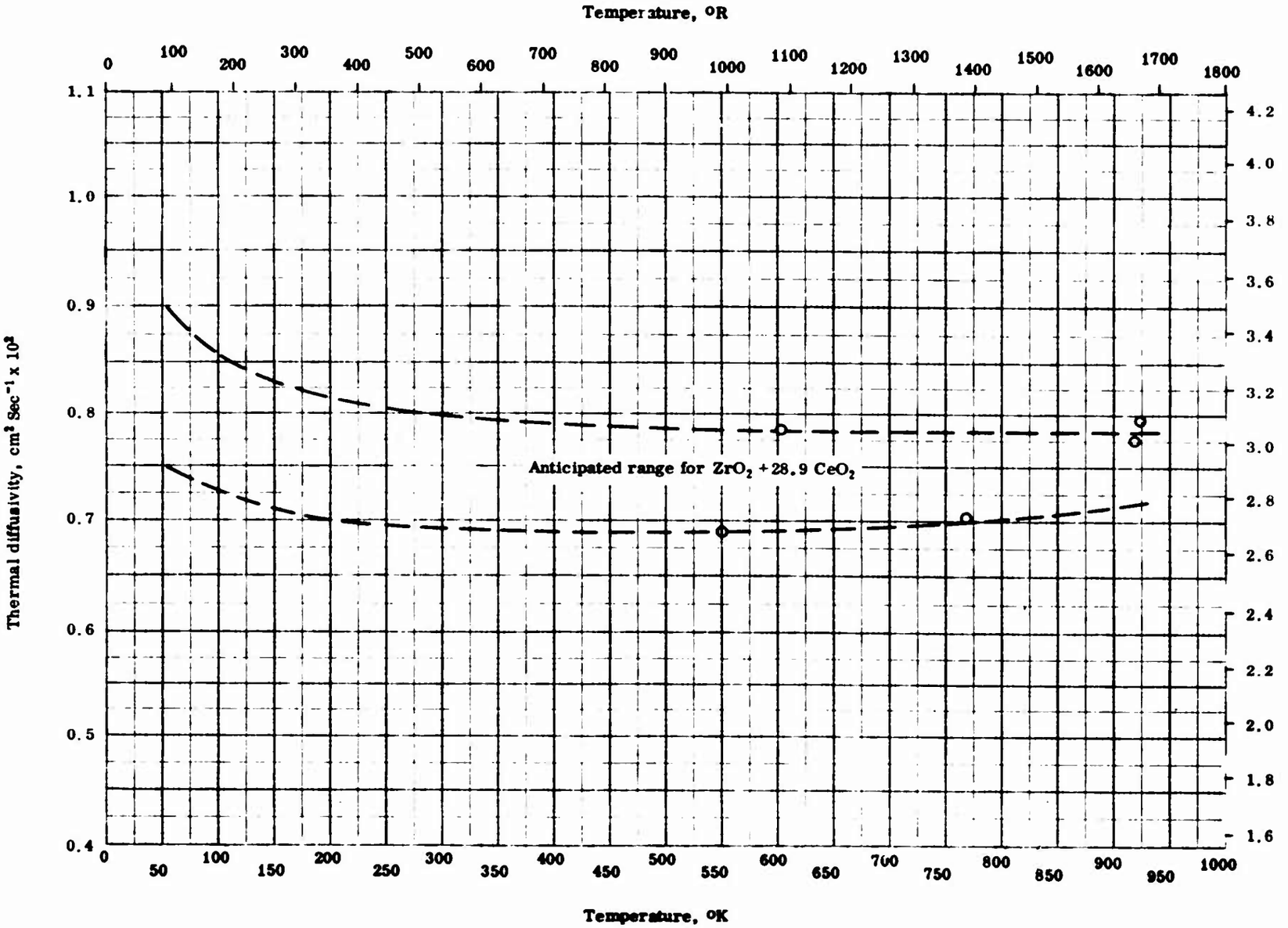


THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + CALCIUM OXIDE + SILICON DIOXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE +CALCIUM OXIDE + SILICON DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	56-11	293-1395		85.28 ZrO_2, 10 CaO, 3.11 SiO_2, and 1.15 (Al_2O_3 + Fe_2O_3 + TiO_2) .	Calcined ZrO_2 (250 mesh) mixed with CaO at 1600 C for 2 hrs, dry pressed at 12,000 psi, and fired 2 hrs at 1600 C.



THERMAL DIFFUSIVITY -- ZIRCONIUM DIOXIDE + CERIUM DIOXIDE

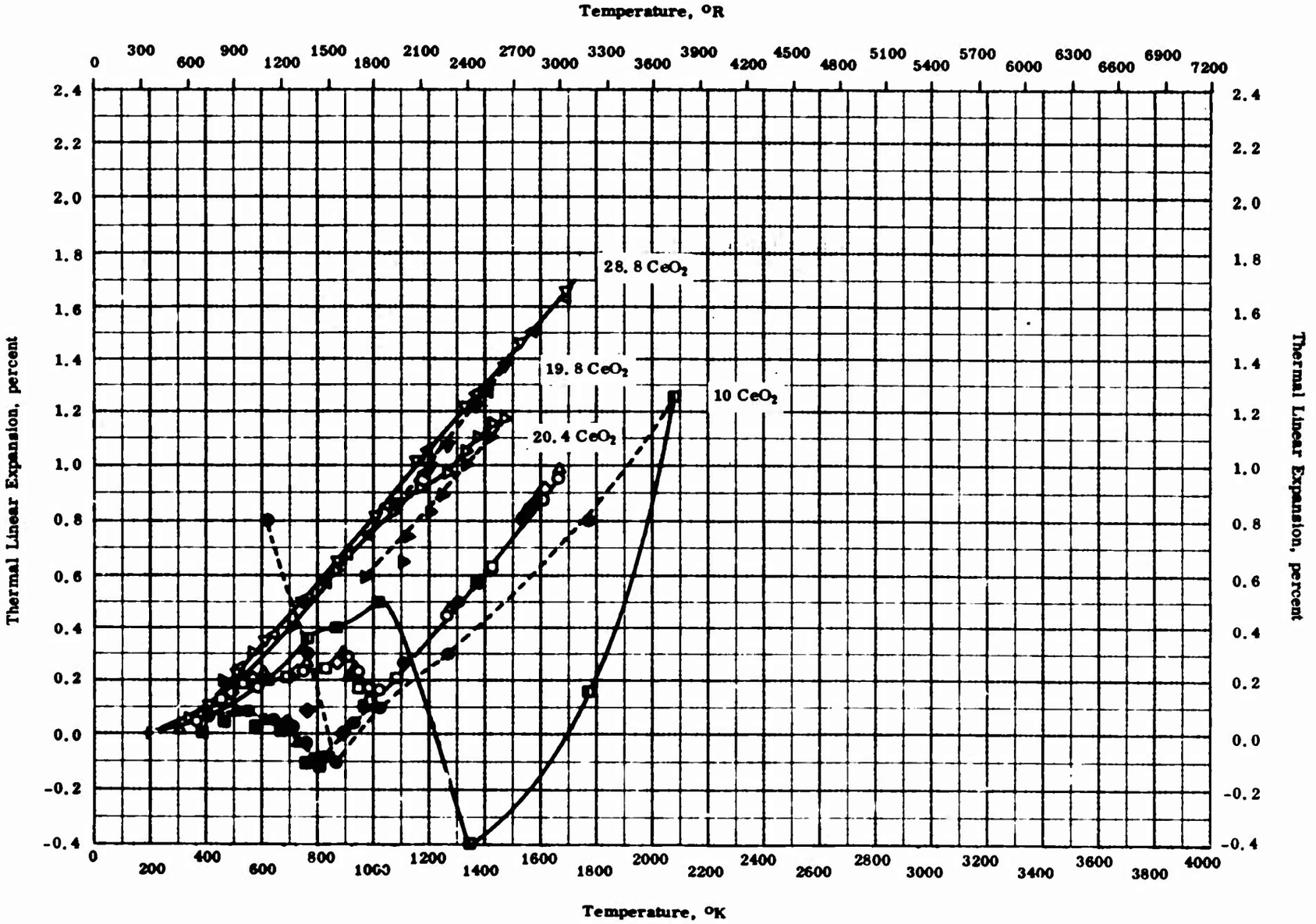
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THERMAL DIFFUSIVITY -- ZIRCONIUM DIOXIDE + CERIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	63-3	550-923		71.1 ZrO_2 and 28.9 CeO_2; corresponding to 22.5 mole % CeO_2.	Zirconia stabiled; sintered at 1850-60 C, soaked for 2 hrs at that temperature in Remmy furnace and cooled with it; all surface ground; only the anticipated range given as recommended values for this composition.

TPRC



THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + CERIUM DIOXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + CERIUM DIOXIDE

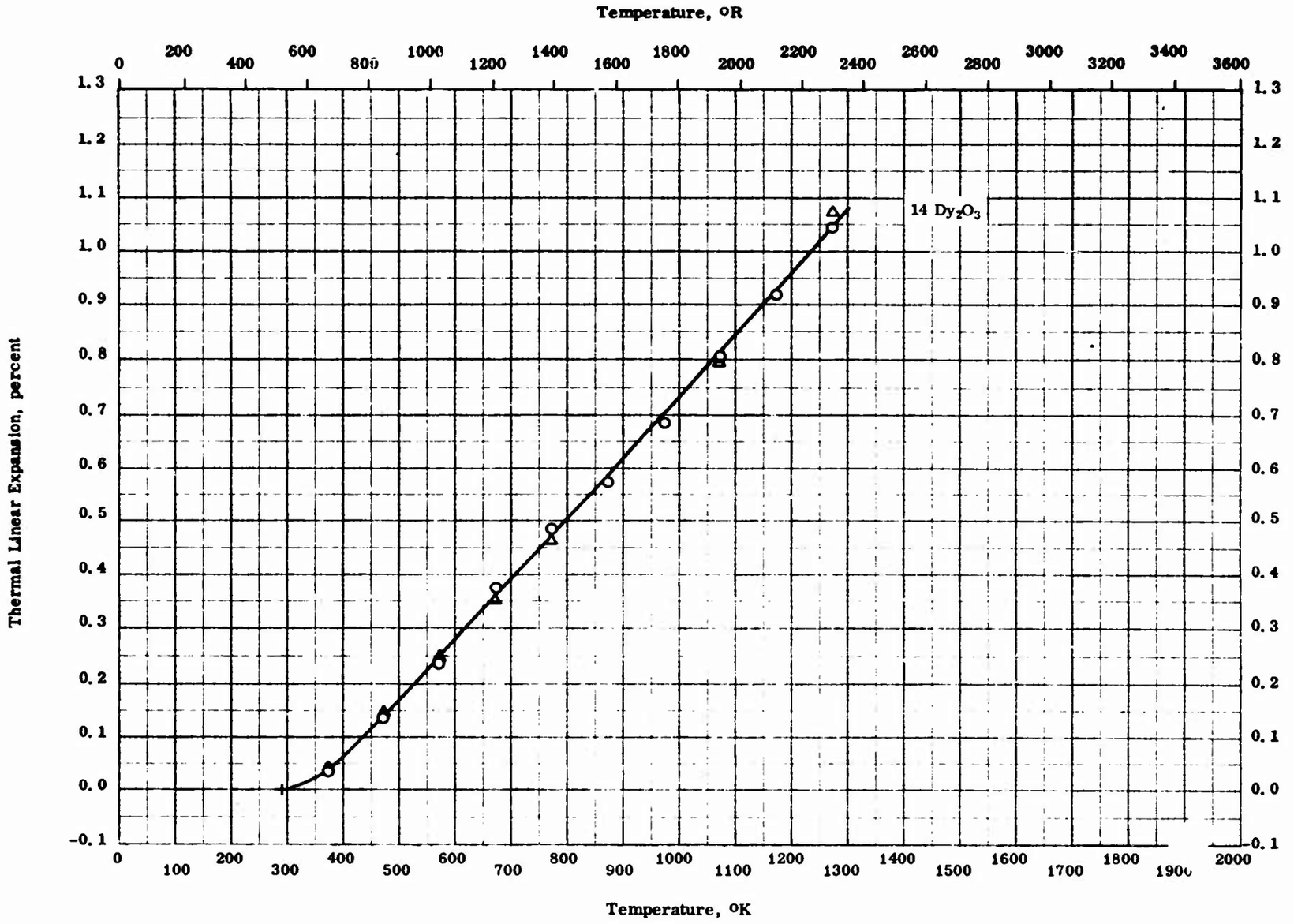
REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	63-3	293-1665		79.60 ZrO_2 and 20.40 CeO_2 from Aeronautical Research Laboratories, Wright-Patterson AF Base; dimensions 3/4 in. long by 3/8 in.^{2} [Author's design: Run 1]	Cold pressed, sintered at 1850 - 1860 C, soaked 2 hrs at temperature, cooled, and cut into bars; measured with heating rate of approx 2.5 C min^{-1} in "stagnant" oxidizing atm; monoclinic to tetragonal inversion occurred in 650 - 744 C range.
●	63-3	415-1537		Same as above.	Cooling cycle for above sample; tetragonal to monoclinic inversion occurred at about 525 C.
△	63-3	311-1665		Same as above. [Author's design: Run 2]	Second heating cycle for above sample.
▲	63-3	411-1547		Same as above.	Second cooling cycle for above sample.
□	63-3	293-1425		Same as above. [Author's design: Run 3]	Third heating cycle for above sample.
■	63-3	393-1377		Same as above.	Third cooling cycle for above sample.
◇	63-3	293-1673		Same as above. [Author's design: Run 4]	Fourth heating cycle for above sample.
◆	63-3	379-1571		Same as above.	Fourth cooling cycle for above sample.
▽	63-3	293-1686		71.16 ZrO_2 and 28.84 CeO_2 from Aeronautical Research Laboratories, Wright-Patterson AF Base; dimensions 3/4 in. long by 3/8 in.^{2} [Author's design: Run 1]	Cold pressed, sintered at 1850 - 1860 C, soaked 2 hrs at temperature, cooled, and cut into bars; measured with heating rate of approx 2.5 C min^{-1} in "stagnant" oxidizing atm; author states that data suggests that 28.84 CeO_2 stabilizes ZrO_2 in tetragonal form at least down to room temperature.
▼	63-3	1099-1467		Same as above.	Cooling cycle for above sample.

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REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◁	63-3	293-1686		Same as above. [Author's design: Run 2]	Second heating cycle for above sample.
◀	63-3	315-1569		Same as above.	Second cooling cycle for above sample.
▷	56-31	273-1471		80.2 ZrO_2 and 19.8 CeO_2; x-ray analysis showed 75 tetragonal (solution of CeO_2 in ZrO_2), 20 monoclinic (not enough CeO_2 to suppress transformation), and the rest unmodified CeO_2.	Heating cycle.
▶	56-31	293-1423		Same as above.	Cooling cycle for above sample.
◧	49-9	273-2073		90 ZrO_2 and 10 CeO_2; density 301 lb ft^{-3}.	Baked at 2100 C.
◐	49-9	623-1773		Same as above.	Cooling cycle for above sample.



THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + DYSPROSIUM OXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + DYSPROSIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifi[illegible]	Remarks
○	60-38	303-1273		86.0 ZrO_2 and 14.0 Dy_2O_3.	Prepared by wet milling with flint pebbles for 2 hrs, dry pressed at 20,000 lb $in.^{-2}$ with 2 soluble wax emulsion into pellets 1/2 in. in diameter by 1 in. long, and fired for 1 hr.
△	60-38	303-1273		Same as above.	Same as above.

TPRC

PROPERTIES OF ZIRCONIUM DIOXIDE + HAFNIUM DIOXIDE

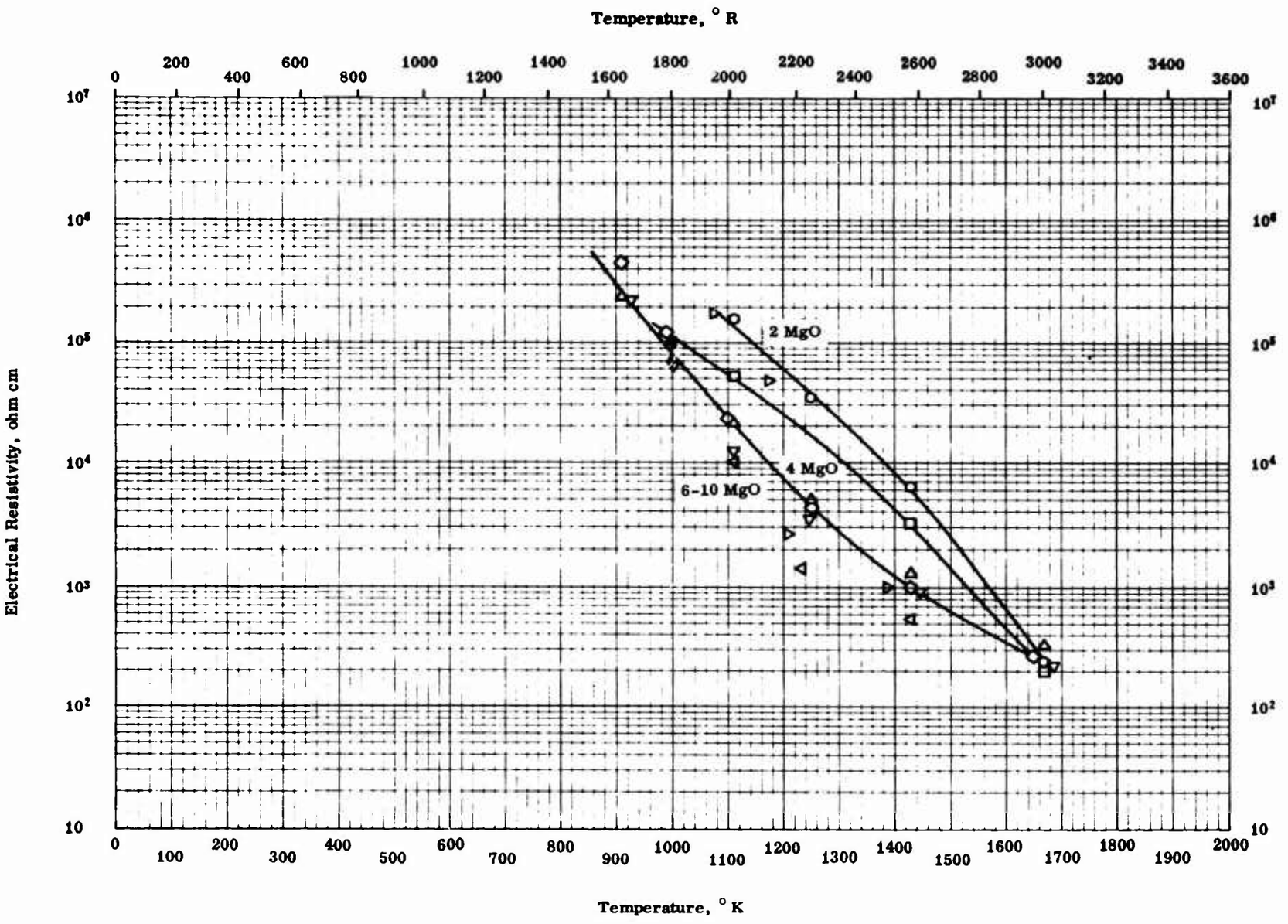
REPORTED VALUES

Melting Point	K	R
O 2.03 HfO_2	2983 ±15	5370 ± 27

PROPERTIES OF ZIRCONIUM DIOXIDE + HAFNIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	52-15	2968-2998		ZrO_2 with 2.03 HfO_2 and 0.03 others.	M.P. by visual observation.

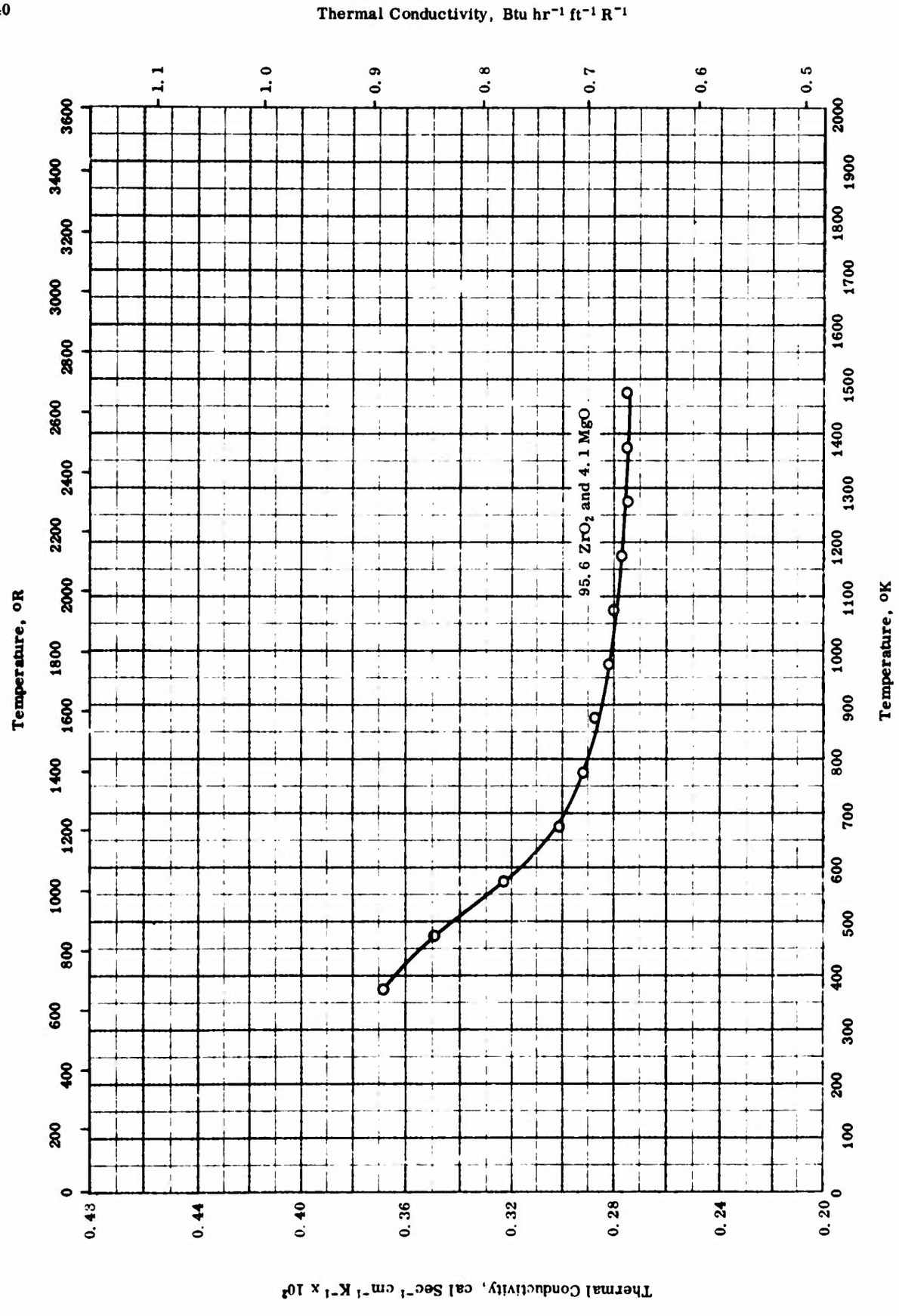


ELECTRICAL RESISTIVITY -- ZIRCONIUM DIOXIDE + MAGNESIUM OXIDE

ELECTRICAL RESISTIVITY -- ZIRCONIUM DIOXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	56-11	1075-1667		97.61 ZrO_2, 2 MgO and 0.20 SiO_2; from ZrO_2: 99.60 ZrO_2; 0.20 SiO_2; trace Al_2O_3, Fe_2O_3, TiO_2; density 362 lb ft^{-3}.	Heating.
▷	56-11	1075-1667		Same as above.	Cooling.
□	56-11	1000-1667		95.62 ZrO_2, 4 MgO, and 0.19 SiO_2; same as above.	Heating.
◁	56-11	1000-1667		Same as above.	Cooling.
△	56-11	909-1667		93-62 ZrO_2, 6 MgO, and 0.19 SiO_2; same as above.	Average of heating and cooling data.
◇	56-11	909-1667		91.63 ZrO_2, 8 MgO, and 0.18 SiO_2; same as above.	Same as above.
▽	56-11	909-1667		89.64 ZrO_2, 10 MgO, and 0.18 SiO_2; same as above.	Same as above.

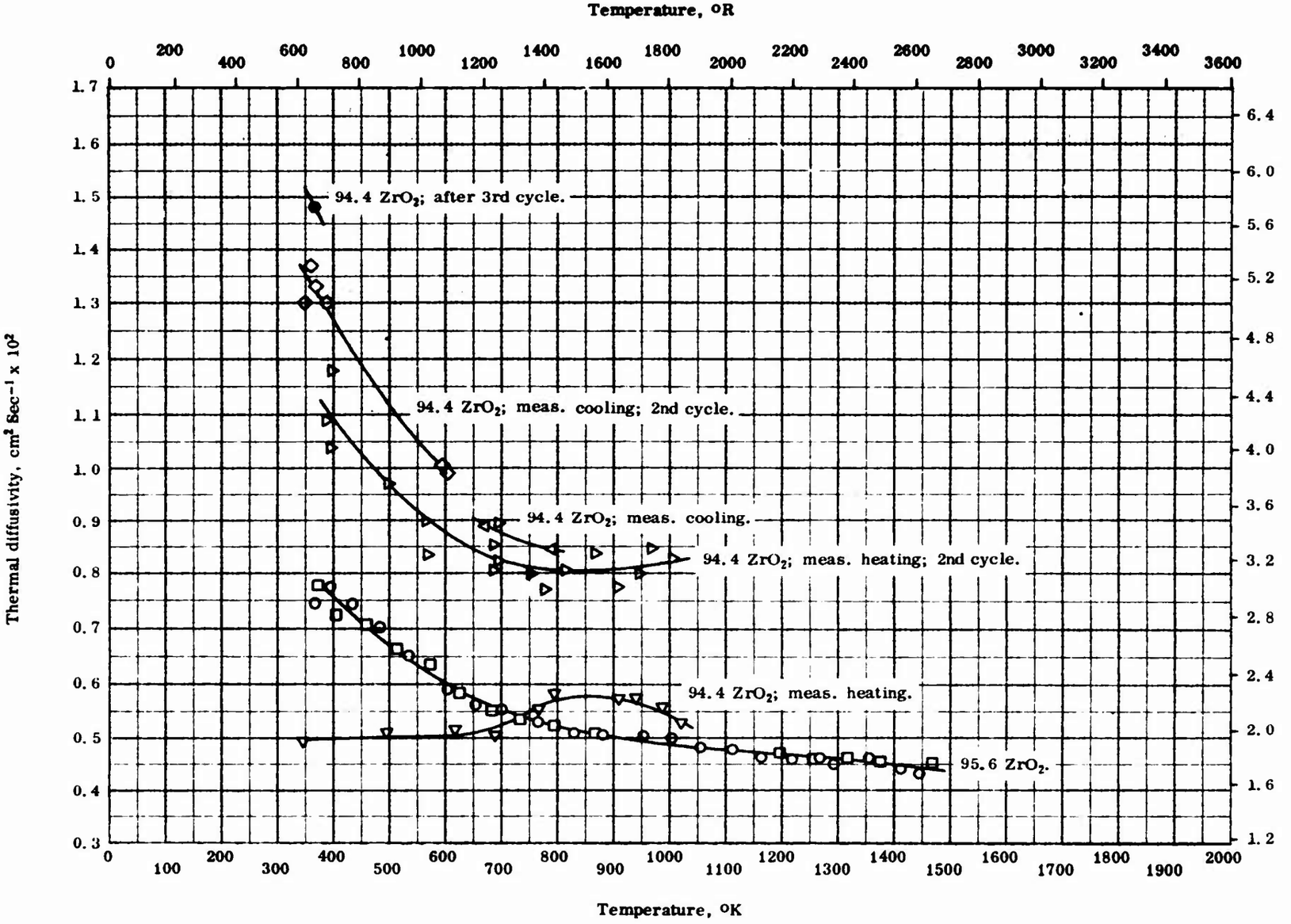


THERMAL CONDUCTIVITY -- ZIRCONIUM DIOXIDE + MAGNESIUM OXIDE

THERMAL CONDUCTIVITY -- ZIRCONIUM DIOXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	57-1	373-1473		From Corning Glass Works; 95.6 ZrO_2, 4.1 MgO, 0.01 -0.1 CaO, 0.01-0.1 SiO_2, 0.01-0.1 TiO_2, 0.005-0.05 Al_2O_3, 0.001-0.01 Fe_2O_3, 0.005> Na_2O, 0.005> K_2O, 0.005> Li_2O, and 0.005> BaO; bulk density 3.65 g cm^{-3} at 25 C and porosity 35 %.	Fired at about 1000 C for 4 hrs.



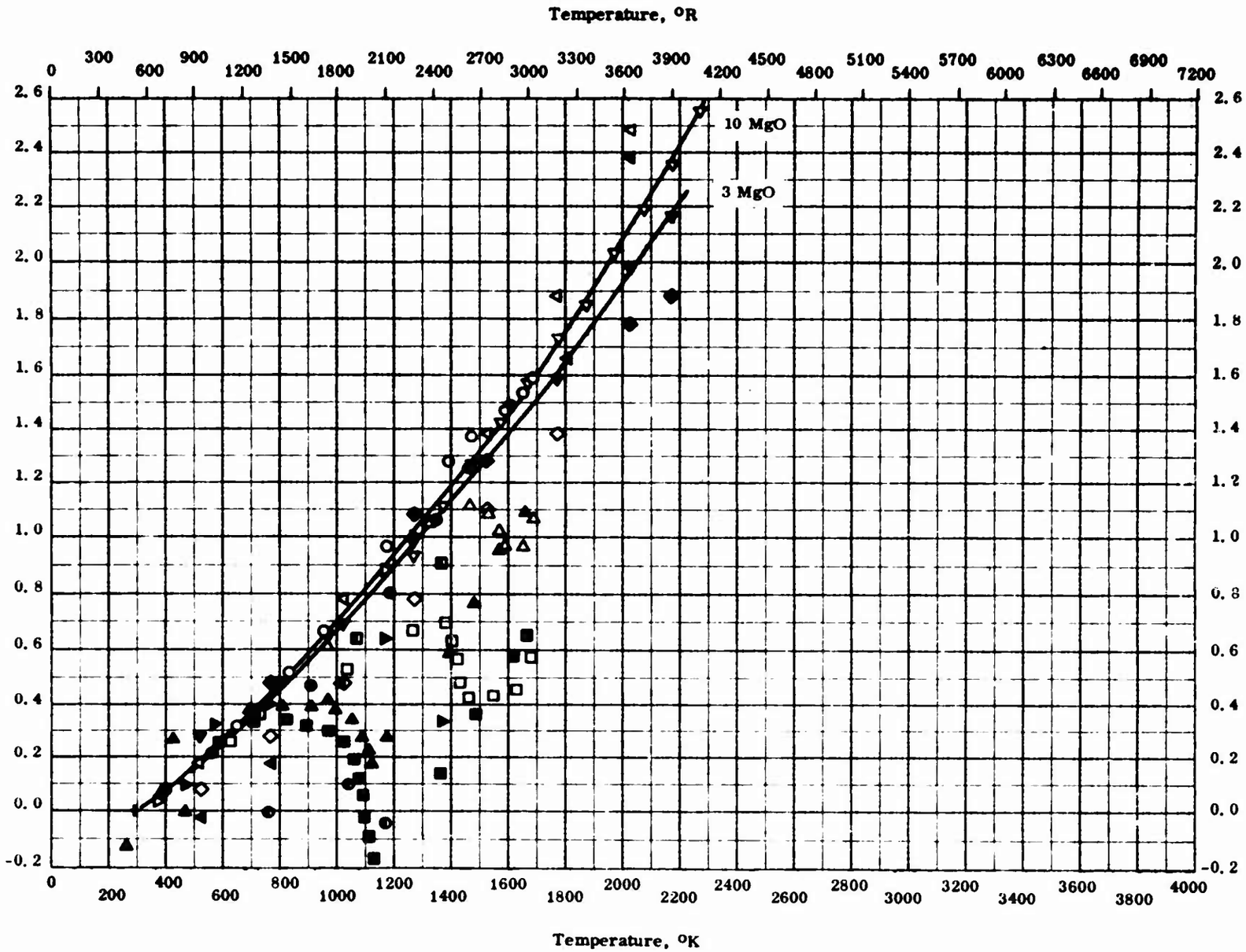
THERMAL DIFFUSIVITY -- ZIRCONIUM DIOXIDE + MAGNESIUM OXIDE

TPRC

THERMAL DIFFUSIVITY -- ZIRCONIUM DIOXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	57-1	366-1445	<5.0	E-109; 95.6 ± 0.1 ZrO_2, 4.1 Mg O, 0.01-0.1 each for SiO_2, TiO_2, and CaO, 0.005-0.05 Al_2O_3, 0.001 to 0.01 Fe_2O_3, and less than 0.005 each of Na_2O, K_2O, Li_2O, and BaO by spectro chemical analysis; surface irregularities due to porosity; bulk density 3.65 g cm^{-3} at 25C, corresponding to about 35% porosity on the basis that the crystal density is about 5.6 g cm^{-3}.	Fired at a temperature no higher than 1550C before receiving and then ground and fired at about 1000C for 4 hrs.
□	57-1	371-1469	<5.0	Same as above	Same as above except measured at a lower heating rate.
▽	63-3	343-1019		94.4 ZrO_2 and 5.6 MgO; corresponding to 15.5 mole % MgO.	Zirconia stabilized; sintered at 1850-60C, soaked for two hrs at that temperature in Remmy furnace and cooled with it; all surface ground.
◁	63-3	670-788		Same as above	Same as above except measured as temperature decreases.
▷	63-3	388-1003		Same as above	Same as above except measured as temperature increases.
◇	63-3	348-608		Same as above	Same as above except measured as temperature again decreases.
●	63-3	363		Same as above	The above specimen.



THERMAL LINEAR EXPA N -- ZIRCONIUM DIOXIDE + MAGNESIUM OXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + MAGNESIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	63-3	313-1682		94.34 ZrO_2 and 5.66 MgO from Aeronautical Research Laboratories, Wright-Patterson AF Base; dimensions 3/4 in. long by 3/8 in.[2] [Author's design: Run 1]	Cold pressed, sintered at 1850 - 1860 C, soaked 2 hrs at temperature, cooled, and cut into bars; measured with heating rate of 2.5 C min^{-1} in "stagnant" oxidizing atm; author states that slope of curve indicates a cubic structure.
●	63-3	401-1682		Same as above.	Cooling cycle for above sample.
△	63-3	313-1687		Same as above. [Author's design: Run 2]	Second heating cycle for above sample; monoclinic to tetragonal inversion occurred at 1200 to 1300 C.
▲	63-3	429-1687		Same as above.	Second cooling cycle for above sample, tetragonal to monoclinic inversion occurred at about 860 C.
❑	63-3	313-1683		Same as above. [Author's design: Run 3]	Third heating cycle for above sample; monoclinic to tetragonal inversion occurred at 1125 to 1175 C.
■	63-3	497-1683		Same as above.	Third cooling cycle for above sample; tetragonal to monoclinic inversion occurred at about 860 C.
▽	63-36	293-2273		90.0 ZrO_2 and 10.0 MgO; prepared from finely milled specially pure zirconia (99.5 ZrO_2); dimensions 4 by 4 by 20 mm; bulk density 5.34 g cm^{-3}; apparent porosity 0.0%. [Author's design: Body 10]	ZrO_2 stabilized with MgO, pressed at 500 Kg cm^{-2}, and fired at 1730 C; rate of temperature rise 5 - 8 C min^{-1}; measured in vacuum furnace; authors reported average coefficients.
▼	49-9	273-2173		97 ZrO_2 and 3 MgO; prepared from 99* pure ZrO_2 and precipitated MgO.	Melted in solar furnace.

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THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE +MAGNESIUM OXIDE (Continued)

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◇	49-9	273-2173		Same as above.	Cooling cycle for above sample.
◆	49-9	273-2173		Same as above.	Mixed and sintered at 2200 C.
◁	49-9	273-2123		90 ZrO_2 and 10 MgO; raw materials same as above.	Mixed and sintered at 2200 C.
◀	49-9	273-2123		Same as above.	Cooling cycle for above sample.
▷	54-38	273-1273		94.34 ZrO_2 and 5.66 MgO; cubic.	Measured rapidly in high temperature region to reduce reversion to monoclinic type; x-ray diffraction method.
▶	56-11	293-1373		97.61 ZrO_2, 2 MgO, and 0.20 SiO_2.	250 mesh ZrO_2 powder calcined with MgO at 1600 C for 2 hrs, dry pressed at 1 ton cm^{-2}, and fired 2 hrs at 1600 C.
●	56-11	233-1373		Same as above.	Cooling cycle for above sample.
■	56-11	293-1373		91.63 ZrO_2, 8 MgO, and 0.18 SiO_2.	Same as heating cycle for above sample.
▲	56-11	263-1373		Same as above.	Cooling cycle for above sample.

TPRC

PROPERTIES OF ZIRCONIUM DIOXIDE + MAGNESIUM OXIDE + BERYLLIUM OXIDE

REPORTED VALUES

Melting Point	K	R
O 23.6 MgO and 18.25 BeO.	1966 ±5	3540 ± 8

PROPERTIES OF ZIRCONIUM DIOXIDE + MAGNESIUM OXIDE + BERYLLIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-26	1961-1971		58.15 ZrO_2, 23.6 MgO and 18.25 BeO.	Average of 3 - 5 tests; M.P. by visual observation.

PROPERTIES OF ZIRCONIUM DIOXIDE + NIOBIUM PENTOXIDE

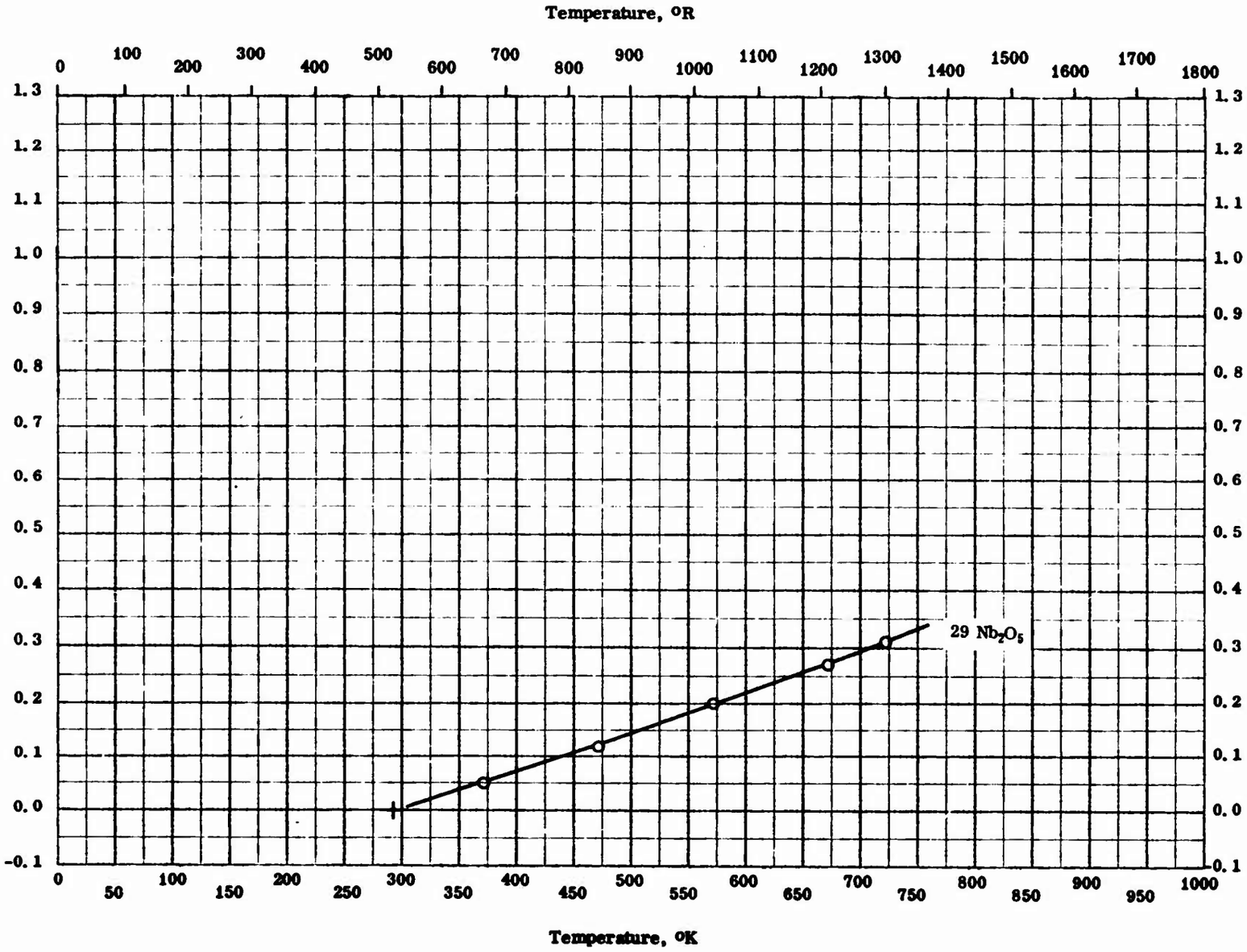
REPORTED VALUES

Melting Point		K	R
○	40.2 Nb_2O_5	1784	3228
□	33.5 Nb_2O_5	1748	3147

PROPERTIES OF ZIRCONIUM DIOXIDE + NIOBIUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	52-12	1784		59.6 ZrO_2 and 40.2 Nb_2O_5; prepared from 99.5+ ZrO_2 and 99.9 Nb_2O_5.	Sintered; M.P. from fusion temperature during sintering.
□	52-12	1748		66.5 ZrO_2 and 33.5 Nb_2O_5; same as above.	Same as above.



THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE +NIOBIUM PENTOXIDE

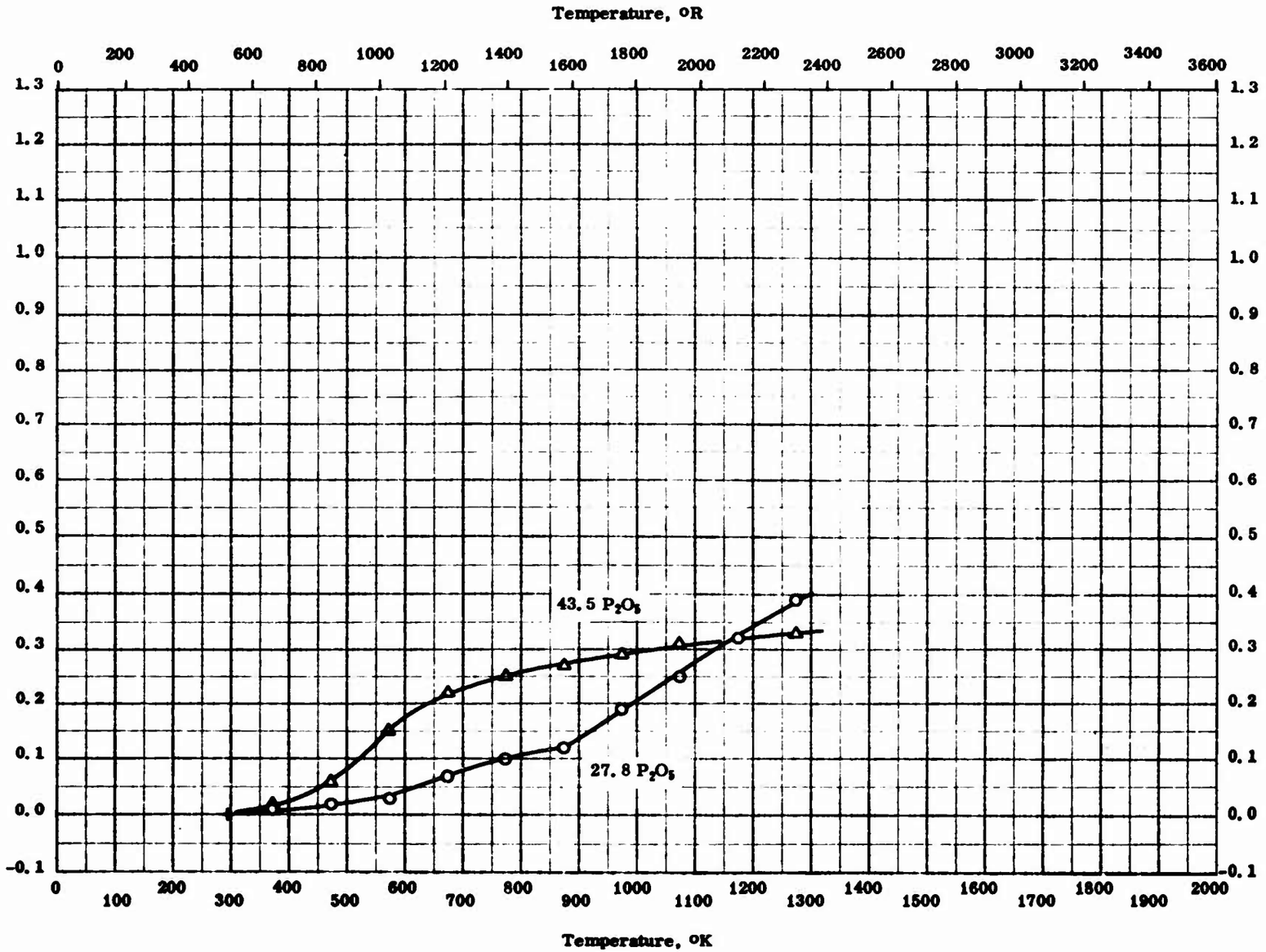
TPRC

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + NIOBIUM PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	52-12	293-723		70.8 ZrO_2 and 29.2 Nb_2O_5; solid solution (3 ZrO_2 + Nb_2O_5) .	Fired 2 hrs at 1485 C and cooled over 24 hr period.

TPRC



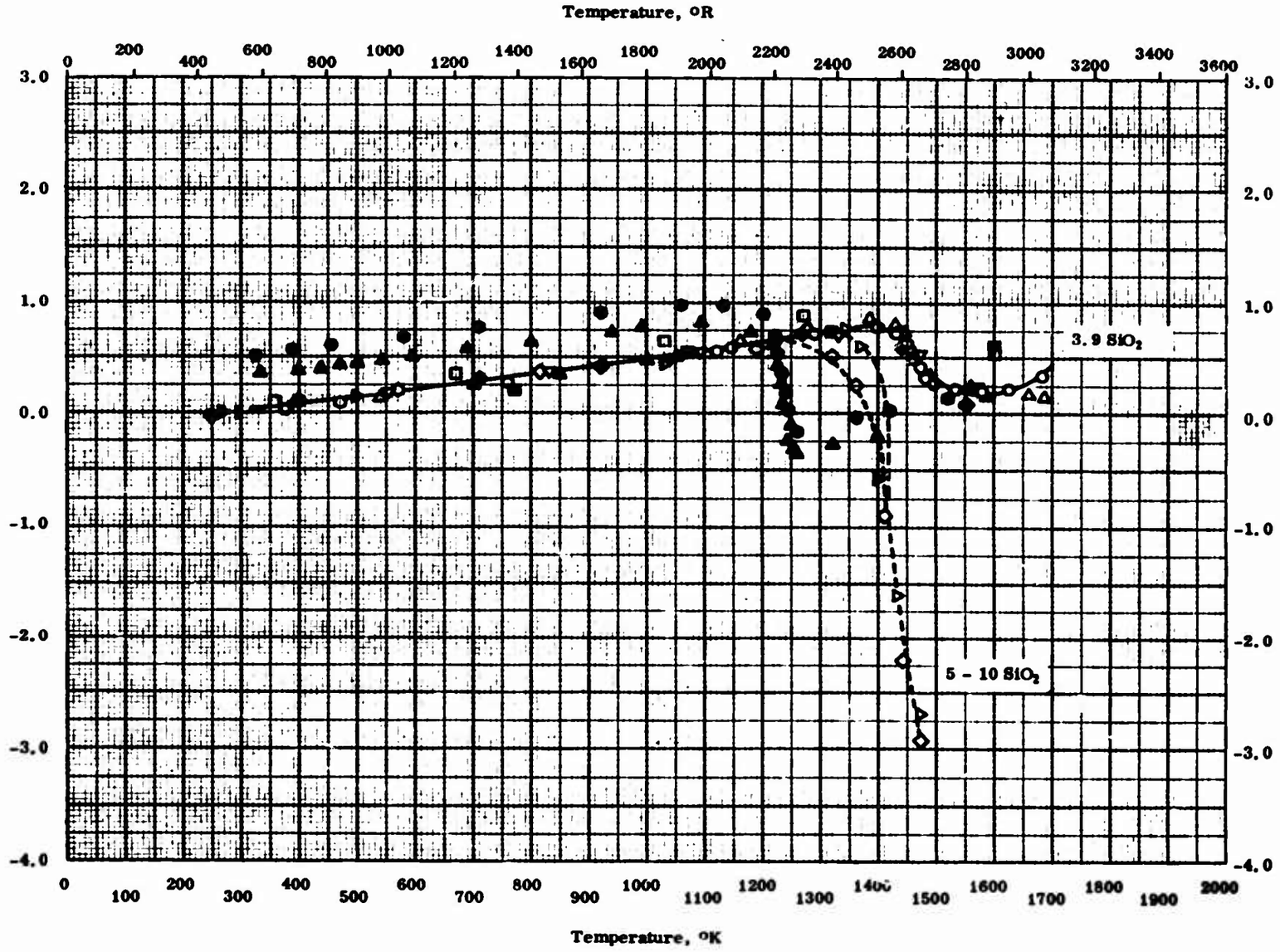
THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + PHOSPHORUS PENTOXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + PHOSPHORUS PENTOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	54-35	293-1273		72.2 ZrO_2 and 27.8 P_2O_5, corresponding to 3 ZrO_2 + P_2O_5.	Mixture calcined 4 hrs at 1550 C.
Δ	54-35	293-1273		56.5 ZrO_2 and 43.5 P_2O_5, corresponding to 3 ZrO_2 + 2 P_2O_5.	Mixture calcined 10 hrs at 1380 C.

TPRC



THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + SILICON DIOXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + SILICON DIOXIDE

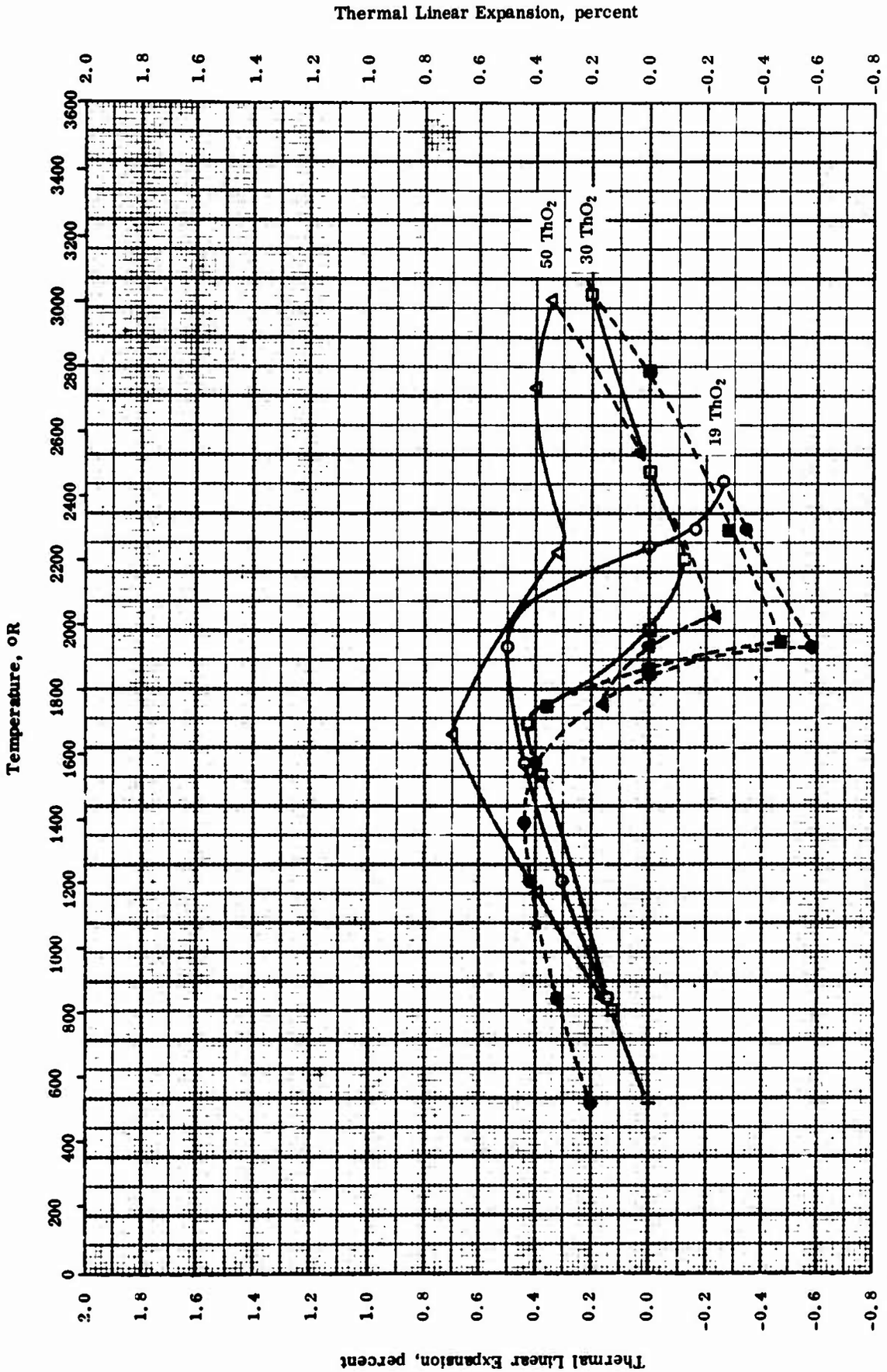
REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	63-3	293-1683		93.77 ZrO_2, 3.90 SiO_2, 0.98 Al_2O_3, 0.75 K_2O, 0.24 MgO, 0.24 TiO_2, 0.14 Na_2O, 0.10 Fe_2O_3, and 0.02 CaO; from Aeronautical Research Laboratories, Wright-Patterson AF Base; prepared from -20 mesh TAM electrically fused, ball milled ZrO_2. [Author's design: Run 171]	ZrO_2 mixed with a suspension of camphor in acetone in the proportions 3 ZrO_2 : 1 camphor by wt., dried, hot-pressed (very little pressure applied initially until temperature corresponding to monoclinic-tetragonal inversion was reached, then pressure applied while specimen passed through inversion; temperature raised to approx 1550 C keeping pressure constant and high pressure held on cooling), cut to shape, surface ground, heat treated at 1000 C for about 6 hrs, and ground to final shape; measured with heating rate of approx 2.5 C min^{-1} in "stagnant" oxidizing atm; monoclinic-tetragonal inversion occurred in 1125 - 1300 C range.
●	63-3	329-1683		Same as above.	Cooling cycle for above sample; tetragonal-monoclinic inversion occurred in 980 - 800 C range.
△	63-3	293-1688		Same as above. [Author's design: Run 172]	Second heating cycle for above sample.
▲	63-3	335-1688		Same as above.	Second cooling cycle for above sample.
▷	52-3	273-1473		94.86 ZrO_2 and 5.14 SiO_2.	Heated 3 hrs at 1000 C.
□	52-3	288-1603		Same as above.	Heated 3 hrs at 1150 C.
■	52-3	288-1603		Same as above.	Heated 3 hrs at 1350 C.

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REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
◇	52-3	288-1473		89.13 ZrO_2 and 10.87 SiO_2.	Heated 3 hrs at 1000 C.
◆	52-3	288-1553		Same as above.	Heated 3 hrs at 1150 C.
▽	52-3	288-1573		Same as above.	Heated 3 hrs at 1350 C.

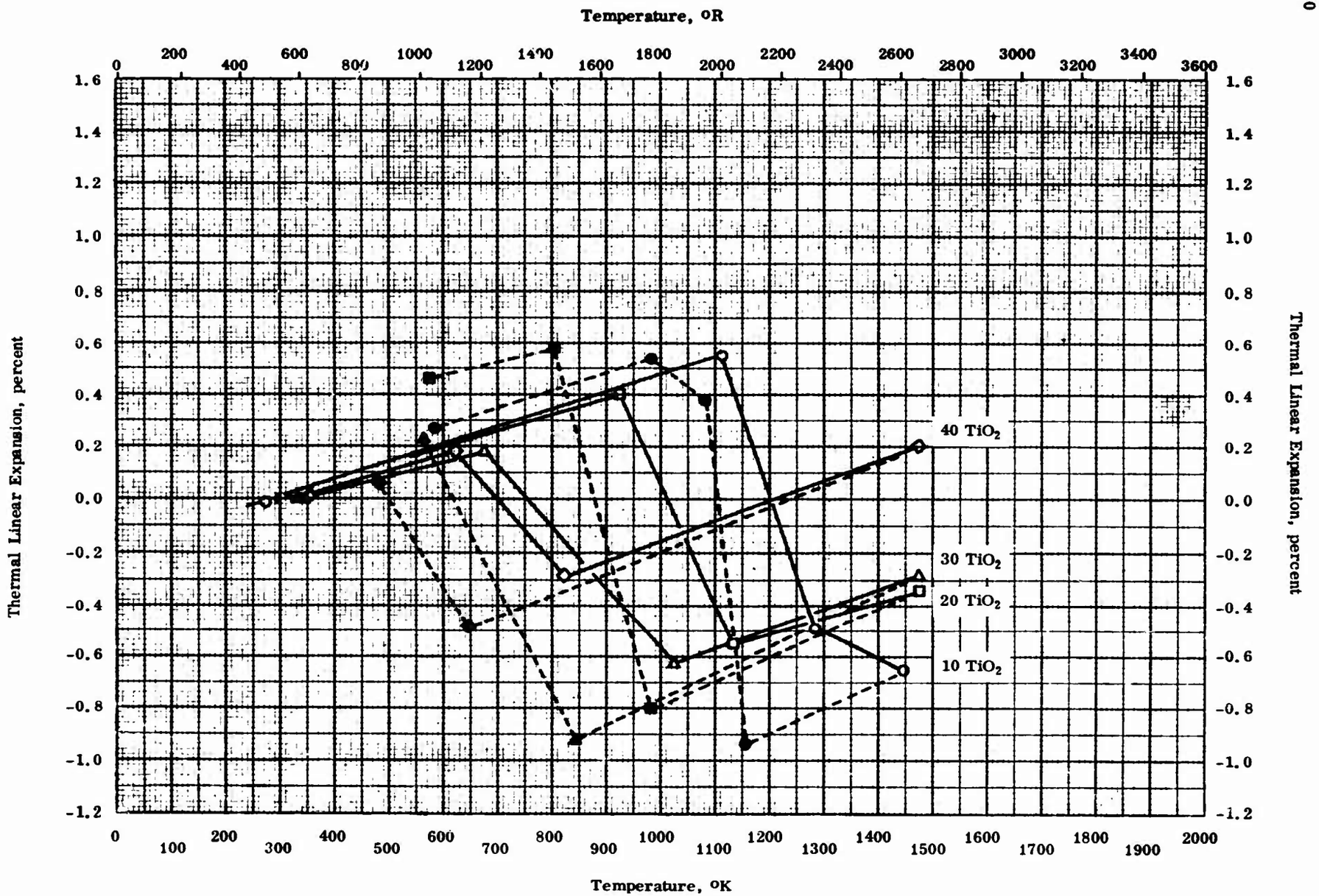


THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE +THORIUM DIOXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + THORIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	57-42	293-1353		81.76 ZrO_2 and 19.24 ThO_2; prepared from 99.7 pure ZrO_2 and 99* pure ThO_2.	Sintered at 1350 C.
●	57-42	293-1353		Same as above.	Cooling cycle for above sample.
□	57-41	453-1673		70 ZrO_2 and 30 ThO_2; ZrO_2 analysis: 97.8 ZrO_2, 0.57 SiO_2, 0.40 H_2O, 0.23 TiO_2, 0.16 Fe_2O_3, 1.61 ignition loss, and trace of MgO and CaO.	Component dry mixed in agate mortar, 5% dextrolyne added as binder, pressed at 1000 kg cm^{-2}, fired to 1700 C in 5 1/2 hrs, soaked 1 hr, and cooled overnight; heated to 1000 C at 10 C min^{-1} and 1000 - 1400 C at 7 C min^{-1}; cooled to 800 C at 10 C min^{-1}, then to room temperature naturally.
■	57-41	973-1673		Same as above.	Cooling cycle for above sample.
△	57-41	473-1663		50 ZrO_2 and 50 ThO_2; raw materials same as above.	Same as heating cycle for above sample.
▲	57-41	973-1663		Same as above.	Cooling cycle for above sample.



THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE +TITANIUM DIOXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + TITANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	54-37	273-1443		90 ZrO_2 and 10 TiO_2; prepared from 99 pure ZrO_2 and c. p. anatase.	Mixed, pressed at 15,000 psi, fired 2 hrs at 1760 C in oxidizing atm, 336 hrs at 1370 C in air, and 1465 hrs at 980 C in air.
●	54-37	583-1443		Same as above.	Cooling cycle for above sample.
□	54-37	273-1473		80 ZrO_2, and 20 TiO_2; raw materials same as above.	Same as heating cycle for above sample.
■	54-37	573-1473		Same as above.	Cooling cycle for above sample.
△	54-37	273-1473		70 ZrO_2 and 30 TiO_2; raw materials same as above.	Same as heating cycle for above sample.
▲	54-37	563-1473		Same as above.	Cooling cycle for above sample.
◇	54-37	273-1473		60 ZrO_2 and 40 TiO_2; raw materials same as above.	Same as heating cycle for above sample.
◆	54-37	483-1473		Same as above.	Cooling cycle for above sample.

PROPERTIES OF ZIRCONIUM DIOXIDE + URANIUM DIOXIDE

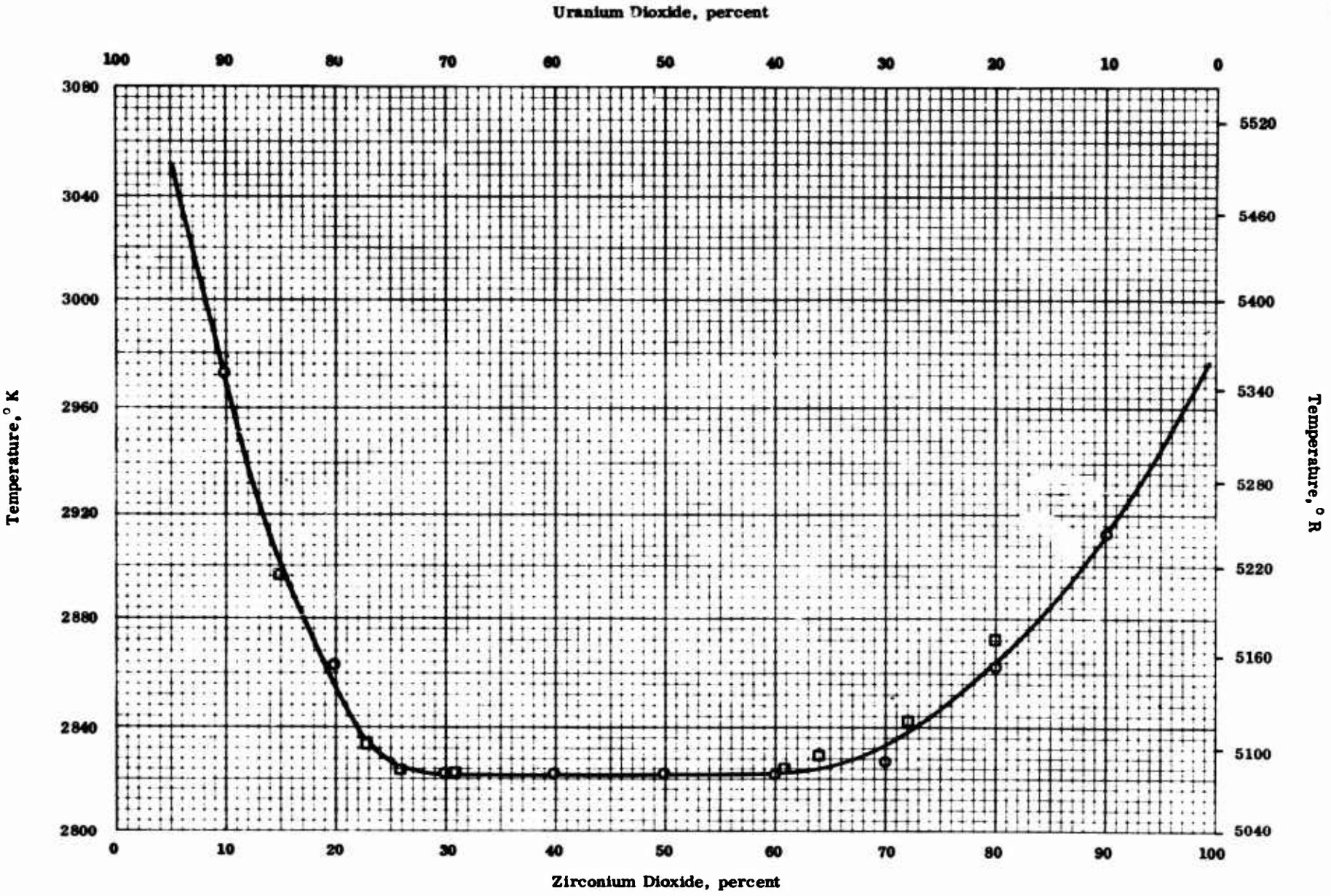
REPORTED VALUES

Density		$g\ cm^{-3}$	$lb\ ft^{-3}$
○	10 UO_2	5.18	323
□	15 UO_2	5.45	340
Melting Point		See figure.	

PROPERTIES OF ZIRCONIUM DIOXIDE + URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	56-26	298		90 ZrO_2 and 10 UO_2.	Pressed at 80,000 psi and sintered 16 hrs at 1700 C.
□	56-26	298		85 ZrO_2 and 15 UO_2.	Same as above except sintered 18 hrs at 1750 C.

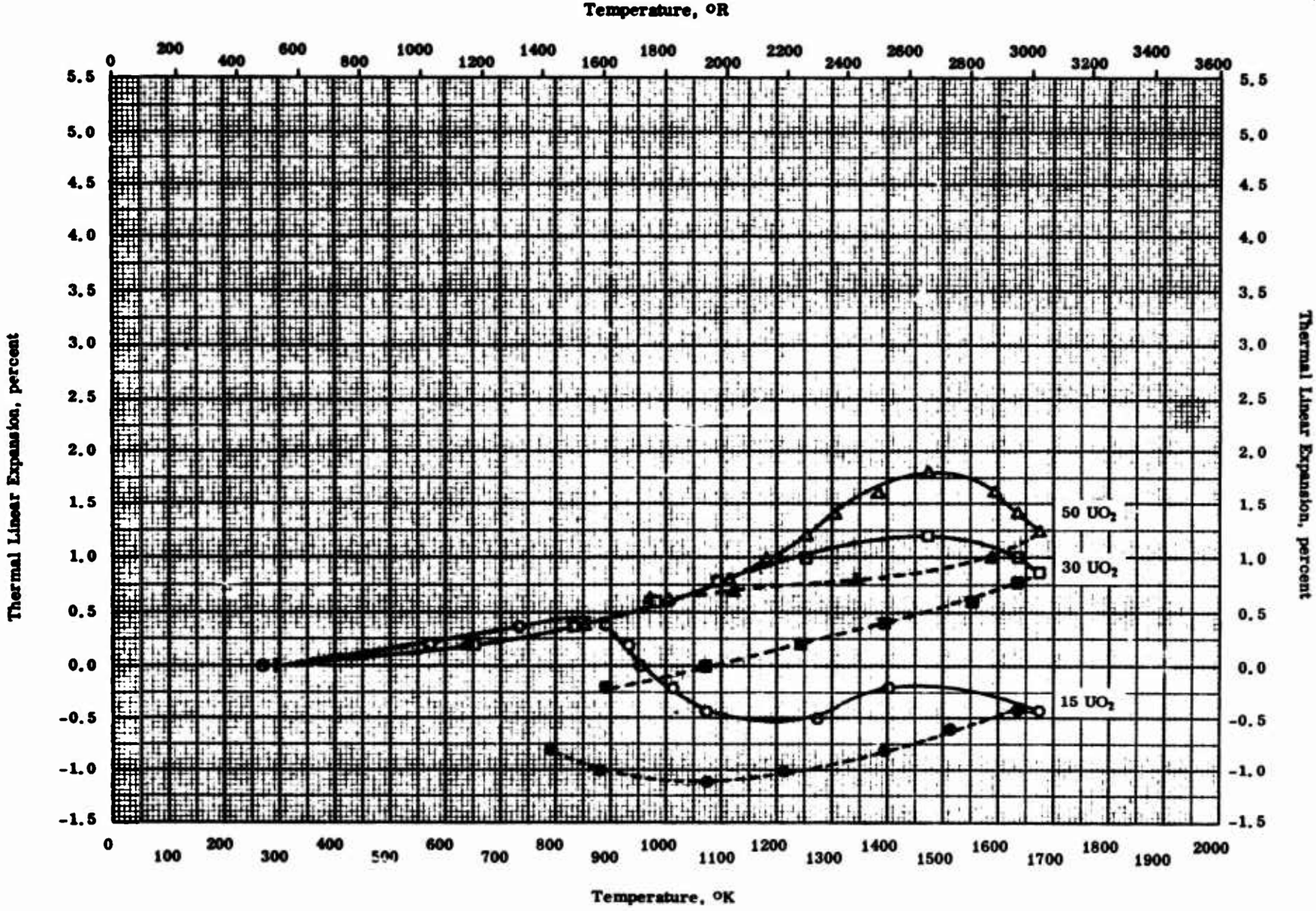


MELTING POINT -- ZIRCONIUM DIOXIDE + URANIUM DIOXIDE

MELTING POINT -- ZIRCONIUM DIOXIDE + URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	53-28	2823-2973		0-100 ZrO_2; made from ≈ 98 ZrO_2 (with 2.0 Hf and 0.035 other impurities) and probably pure UO_2.	
□	53-28	2834-2896		Same as above.	

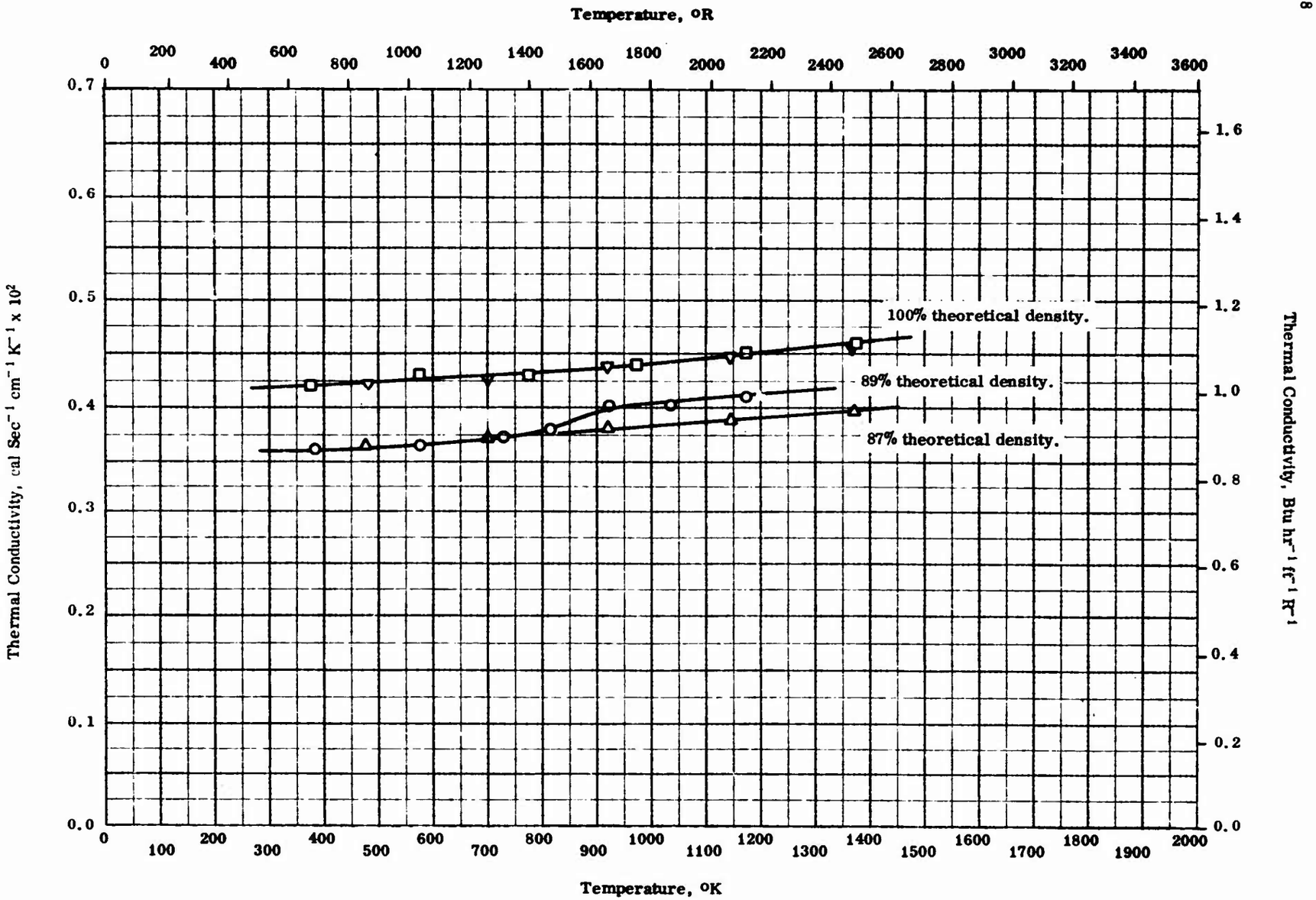


THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + URANIUM DIOXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + URANIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	57-41	273-1673		85 ZrO_2 and 15 UO_2; ZrO_2 analysis: 97.0 ZrO_2, 0.57 SiO_2, 0.40 H_2O, 0.23 TiO_2, 0.16 Fe_2O_3, 1.61 ignition loss, and trace of MgO and CaO; UO_2 prepared from U_3O_8 heated 1 hr at 650 C in H_2 atm.	Components dry mixed in agate mortar, 5 dextrolyne added as binder, pressed at 1000 Kg cm^{-2}, fired to 1700 C in 5 1/2 hrs, soaked 1 hr, and cooled overnight; heated to 1000 C at 10 C min^{-1} and 1000 - 1400 C at 7 C min^{-1}; cooled to 800 C at 10 C min^{-1}, then to room temperature naturally.
●	57-41	793-1673		Same as above.	Cooling cycle for above sample.
□	57-41	273-1673		70 ZrO_2 and 30 UO_2; raw materials same as above.	Same as heating cycle for above sample.
■	57-41	893-1673		Same as above.	Cooling cycle for above sample.
△	57-41	273-1673		50 ZrO_2 and 50 UO_2; raw materials same as above.	Same as heating cycle for above sample.
▲	57-41	973-1673		Same as above.	Cooling cycle for above sample.

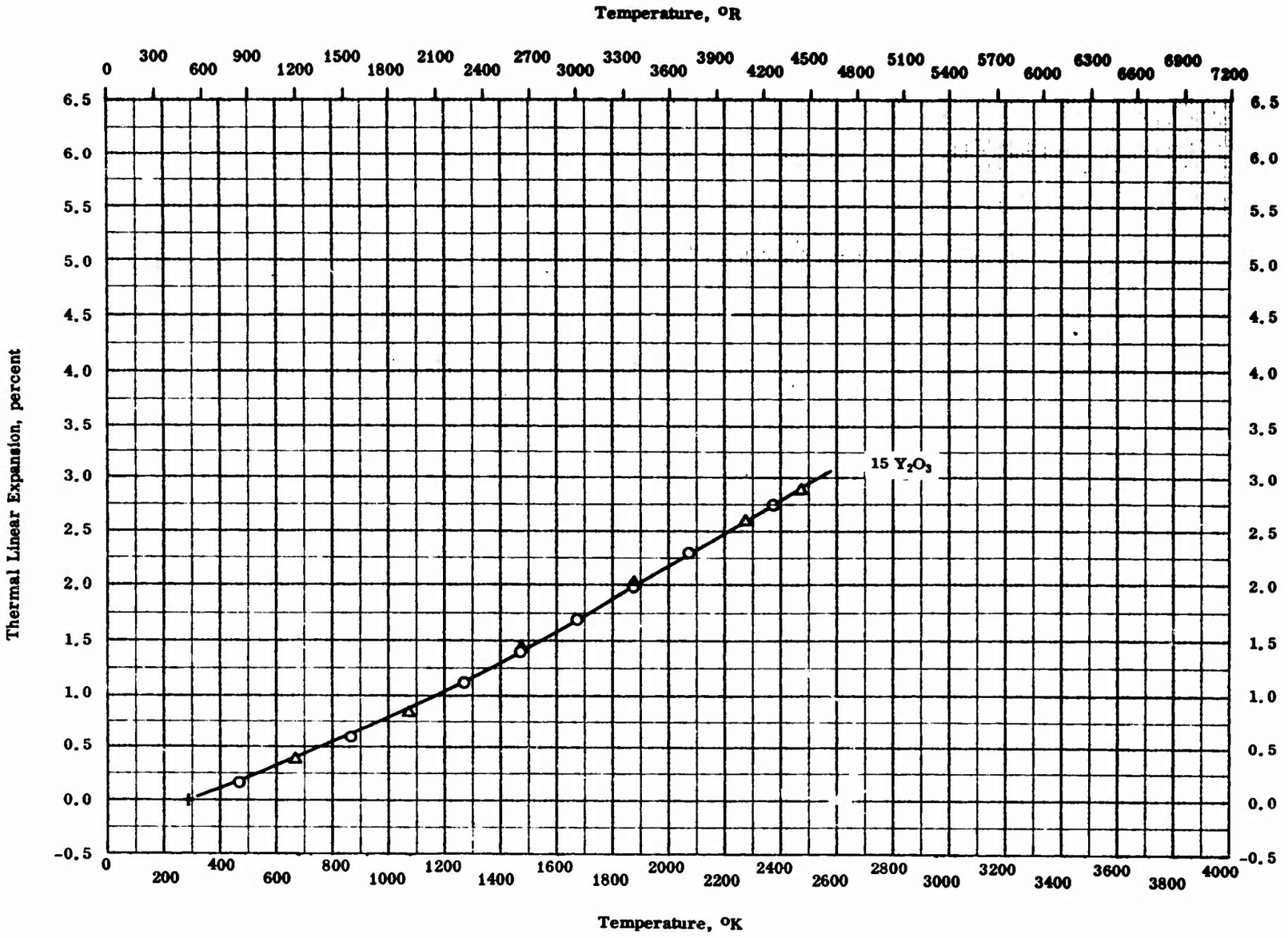


THERMAL CONDUCTIVITY -- ZIRCONIUM DIOXIDE + YTTRIUM OXIDE

THERMAL CONDUCTIVITY -- ZIRCONIUM DIOXIDE + YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
○	61-10	383-1174		15 Y_2O_3; bulk density 5.17 g cm^{-3} (88.74% of theoretical density).	ZrO_2 stabilized.
□	61-10	373-1373		Same as above.	Same as above; data corrected to theoretical density.
△	61-5	478-1367		15 Y_2O_3; prepared by Columbia National ZrO_2 and Michigan Chem. Y_2O_3; 86.7% of theoretical density.	Raw materials prereacted at 3000 F; dry-pressed followed by isostatic compaction and then sintered at 3100 F in air for 2 hrs.
▽	61-5	478-1367		Same as above.	Data corrected to 100% theoretical density.

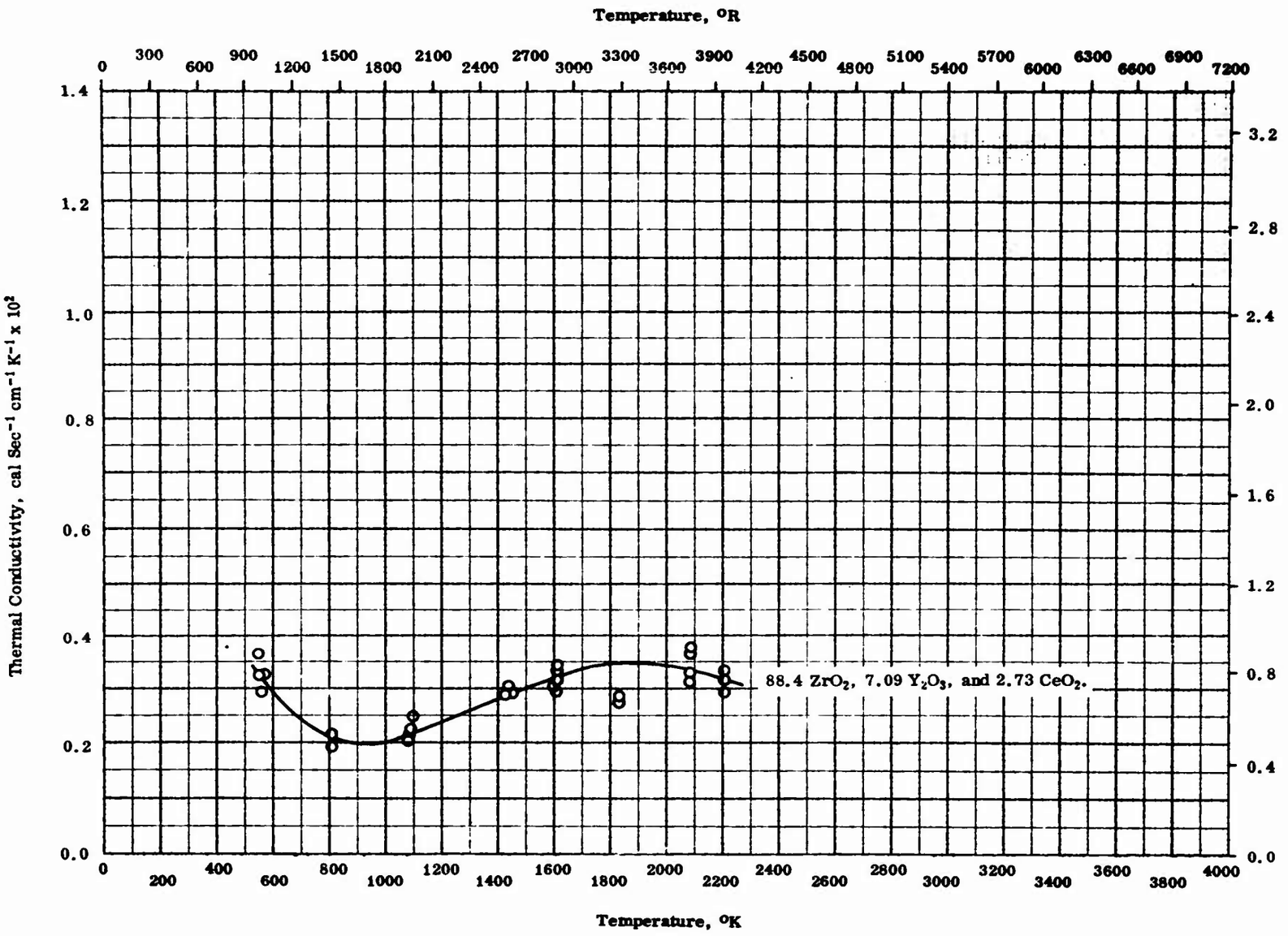


THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + YTTRIUM OXIDE

THERMAL LINEAR EXPANSION -- ZIRCONIUM DIOXIDE + YTTRIUM OXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	64-31	298-2373		ZrO_2 and 15 Y_2O_3; impurities : 1 Hf, 0.2 Al, 0.15 Si, and 0.1 Mg; density 5.60 g cm^{-3}.	Mixture calcined at 1725 C for 6 hrs, pulverized, aqueous slip cast into slugs, and fired at 1700 C for 24 hrs in oxidizing atm; measured in air atm.
△	64-31	298-2473		Same as above except density 5.56 g cm^{-3}.	Same as above except measured in 95 oxygen and 5 nitrogen atm.



THERMAL CONDUCTIVITY -- ZIRCONIUM DIOXIDE + YTTRIUM OXIDE + CERIUM DIOXIDE

THERMAL CONDUCTIVITY -- ZIRCONIUM DIOXIDE + YTTRIUM OXIDE + CERIUM DIOXIDE

REFERENCE INFORMATION

Symbol	Ref.	Temp. Range °K	Rept. Error %	Sample Specifications	Remarks
O	62-5	549-2206		88.41 ZrO_2, 7.09 Y_2O_3, 2.73 CeO_2, 0.702 minor oxides, 0.46 CaO, 0.25 MgO, 0.25 SiO_2, 0.063 $CaSO_4$, and 0.045 SO_4; coarse grain; made from 89.3 ZrO_2 (with 0.52 CaO, 0.28 SiO_2, 0.28 MgO, 0.07 $CaSO_4$, and 0.05 SO_4), 7.8 Y_2O_3 (with 0.8 CeO_2 and 4.27 minor oxides), and 2.9 CeO_2 (with 7.6 minor oxides); density 0.167 lb in^{-3} and porosity 22.58%.	Stabilized zirconia; molded.